U.S.S.D.

BUILDER 1 & C

BUREAU OF NAVAL PERSONNEL

RATE TRAINING MANUAL NAVPERS 10649-E

PREFACE

This book is intended to serve as an aid for men who are seeking to acquire the theoretical knowledge and operational skills required of candidates for advancement to the rates of Builder First Class and Chief Builder. As one of the Rate Training Manuals, this book was prepared by the Training Publications Division of the Naval Personnel Program Support Activity, Washington, D.C. The Naval Facilities Engineering Command (formerly Bureau of Yards and Docks), the Naval Examining Center, the Naval Schools Construction, Port Hueneme, California, and the Naval Schools Construction, Davisville, Rhode Island, provided technical assistance and review for technical accuracy.

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THE UNITED STATES NAVY

GUARDIAN OF OUR COUNTRY

The United States Navy is responsible for maintaining control of the sea and is a ready force on watch at home and overseas, capable of strong action to preserve the peace or of instant offensive action to win in war.

It is upon the maintenance of this control that our country's glorious future depends; the United States Navy exists to make it so.

WE SERVE WITH HONOR

Tradition, valor, and victory are the Navy's heritage from the past. To these may be added dedication, discipline, and vigilance as the watchwords of the present and the future.

At home or on distant stations we serve with pride, confident in the respect of our country, our shipmates, and our families.

Our responsibilities sober us; our adversities strengthen us.

Service to God and Country is our special privilege. We serve with honor.

THE FUTURE OF THE NAVY

The Navy will always employ new weapons, new techniques, and greater power to protect and defend the United States on the sea, under the sea, and in the air.

Now and in the future, control of the sea gives the United States her greatest advantage for the maintenance of peace and for victory in war.

Mobility, surprise, dispersal, and offensive power are the keynotes of the new Navy. The roots of the Navy lie in a strong belief in the future, in continued dedication to our tasks, and in reflection on our heritage from the past.

Never have our opportunities and our responsibilities been greater.

CONTENTS

CREDITS

The illustrations listed below are included in this edition of Builder 1 and Chief through the courtesy of the designated sources. Permission to use these illustrations is gratefully acknowledged. Permission to reproduce illustrations and other materials in this publication must be obtained from the source.

Source	Figures
Portland Cement Association	5-17, 5-18

CHAPTER 1

ADVANCEMENT

This training manual is designed to help you meet the occupational qualifications for advancement to Builder First Class and Chief Builder. Chapters 2 through 13 of this training manual deal with the technical subject matter of the Builder rating. The present chapter provides introductory information that will help you in working for advancement. It is strongly recommended that you study this chapter carefully before beginning intensive study of the chapters that follow.

REWARDS AND RESPONSIBILITIES

Advancement brings both increased rewards and increased responsibilities. The time to start looking ahead and considering the rewards and the responsibilities of advancement is right now, while you are preparing for advancement to BU1 or BUC.

By this time, you are probably well aware of many of the advantages of advancement—higher pay, greater prestige, more interesting and challenging work, and the satisfaction of getting ahead in your chosen career. By this time, also, you have probably discovered that one of the most enduring rewards of advancement is the personal satisfaction you find in developing your skills and increasing your knowledge.

The Navy also benefits by your advancement. Highly trained personnel are essential to the functioning of the Navy. By each advancement you increase your value to the Navy in two ways. First, you become more valuable as a technical specialist in your own rating. And second, you become more valuable as a person who can supervise, lead, and train others and thus make far reaching and long lasting contributions to the Navy.

In large measure, the extent of your contribution to the Navy depends upon your willingness and ability to accept increasing responsibilities as you advance. When you assumed the duties of a BU3, you began to accept a certain amount of responsibility for the work of others. With each advancement, you accept an increasing responsibility in military matters and in matters relating to the occupational requirements of the Builder rating.

You will find that your responsibilities for military leadership are about the same as those of petty officers in other ratings, since every petty officer is a military person as well as a technical specialist. Your responsibilities for technical leadership are special to your rating and are directly related to the nature of your work. Erecting a structure is a job of vital importance, and it's a teamwork job. It requires a special kind of leadership ability that can only be developed by personnel who have a high degree of technical competence and a deep sense of personal responsibility.

Certain practical details that relate to your responsibilities for foremanship are discussed in chapter 9 of this training manual. At this point, let's consider some of the broader aspects of your increasing responsibilities for military and technical leadership.

YOUR RESPONSIBILITIES WILL EXTEND BOTH UPWARD AND DOWNWARD. Both officers and enlisted personnel will expect you to translate the general orders given by officers into detailed, practical on-the-job language that can be understood and followed even by relatively inexperienced personnel. In dealing with your juniors, it is up to you to see that they perform their work properly. At the same time, you must be able to explain to officers any important needs or problems of the enlisted men.

YOU WILL HAVE REGULAR AND CONTINUING RESPONSIBILITIES FOR TRAINING. Even if you are fortunate enough to have a number of highly skilled and well trained Builders, you will still find that training is necessary. For example, you will always be responsible for training

lower rated men for advancement. Also, some of your best workers may be transferred and inexperienced or poorly trained personnel may be assigned to you. Or a particular job may call for skills that none of your personnel have. These and similar problems require you to be a training specialist who can conduct formal and informal training programs to qualify personnel for advancement and who can train individuals and groups in the effective execution of assigned tasks.

YOU WILL HAVE INCREASING RESPONSIBILITIES FOR WORKING WITH OTHERS. As you advance to BU1 and then to BUC, you will find that many of your plans and decisions affect a large number of persons. It becomes increasingly important, therefore, to understand the duties and responsibilities of others. Every petty officer in the Navy is a technical specialist in his own field. Learn as much as you can about the work of other ratings, and plan your work so that it will fit in with the overall mission of the organization.

AS YOUR RESPONSIBILITIES INCREASE, YOUR ABILITY TO COMMUNICATE CLEARLY AND EFFECTIVELY MUST ALSO INCREASE. The basic requirement for effective communication is a knowledge of your own language. Use correct language in speaking and in writing. Remember that the basic purpose of all communication is understanding. To lead, supervise, and train others, you must be able to speak and write in such a way that others can understand exactly what you mean.

A second requirement for effective communication in the Navy is a sound knowledge of the Navy way of saying things. Some Navy terms have been standardized for the purpose of ensuring efficient communication. When a situation calls for the use of standard Navy terminology, use it.

Still another requirement of effective communication is precision in the use of technical terms. A command of the technical language of the Builder rating will enable you to receive and convey information accurately and to exchange ideas with others. A person who does not understand the precise meaning of terms used in connection with the work of his own rating is at a disadvantage when he tries to read official publications relating to his work. He is also at a great disadvantage when he takes the written examinations for advancement. Although it is always important for you to use technical terms correctly, it is particularly important when you are dealing with lower rated men. Sloppiness in the use of technical terms is likely to be very confusing to an inexperienced man.

YOU WILL HAVE INCREASED RESPONSIBILITIES FOR KEEPING UP WITH NEW DEVELOPMENTS. Practically everything in the Navy—policies, procedures, equipment, publications, systems—is subject to change and development. As a BU1, and even more so as a BUC, you must keep yourself informed about all changes and new developments that might affect your rating or your work.

Some changes will be called directly to your attention, but others you will have to look for. Try to develop a special kind of alertness for new information. See that you are well informed as to available sources of technical information. And, make a continuing effort to keep up to date on construction methods and equipment. New methods and new equipment are constantly being devised, and existing methods and equipment are subject to modification. If you look back over the history of construction since the end of World War II, you will note a number of important changes which have occurred during this time.

The tilt-up method of erecting concrete walls, for example, was practically unknown at the end of World War II, but is now used extensively. The board sheathing most generally used for forms at the end of World War II has been almost entirely supplanted by plywood. Prestressing for concrete was relatively unknown in 1946. Much of the current paving-train method of highway paving has been devised since that time. Various new and better mixing machines for concrete, mortar, and plaster have come out. Gun-setting of nails in concrete and masonry has been devised. Drop-hammers for pile-driving have given way almost totally to steam and pneumatic hammers. New types of floor tile have appeared. These are only a few of the changes which have occurred; they are noted here simply to show that changes may constantly be expected.

THE BUILDER RATING

Builders plan, supervise, and perform tasks required for construction, maintenance, and repair of wooden, concrete, and masonry structures, concrete pavement, waterfront, and underwater structures; initiate procurement and direct stor-

age of building materials; form and direct efforts of crews to perform rough and finish carpentry; erect and repair waterfront structures, wooden and concrete bridges and trestles; fabricate and erect forms; mix, place, and finish concrete; lay or set masonry; paint and varnish new and refinished surfaces; and operate concrete batch plants.

Most of the billets for BU1 and BUC are allotted to construction battalions. In a battalion a BU1 or BUC usually serves in a construction company, as supervisor of construction crews. Occasional assignment to the planning and estimating or quality control section may occur, for estimating or inspecting in the Builder material and structural categories. A few Builders of high caliber may also be selected to serve as members on Seabee Teams.

Outside of construction battalions, Builders may be assigned to public works departments. Other billets include recruiting duty, recruit training, and Naval Reserve training. A limited number of particularly well qualified Builders are also given assignments to instruct in Navy schools; to assist in making up the servicewide advancement examinations at the Naval Examining Center, Great Lakes; to assist in the preparation of Rate Training Manuals (like this one) and other materials in the Training Publications Division, Naval Personnel Program Support Activity, Washington, D. C.; and to perform other highly specialized duties where their technical knowledge can be utilized effectively for the needs of the service.

REQUIREMENTS FOR ADVANCEMENT

In general, to qualify for advancement you must:

1. Have a certain amount of time in grade.
2. Complete the required military and occupational training courses.
3. Demonstrate the ability to perform all the PRACTICAL requirements for advancement by completing the Record of Practical Factors, NavPers 1414/1 (formerly NavPers 760).
4. Be recommended by your commanding officer.
5. Demonstrate your KNOWLEDGE by passing a written examination based on (a) the military requirements for advancement and (b) the occupational qualifications for advancement.

FINAL MULTIPLE

Advancement is not automatic. Meeting all the requirements makes you eligible for advancement but does not guarantee your advancement. The number of men in each rate and rating is controlled on a Navy-wide basis. Therefore, the number of men that may be advanced is limited by the number of vacancies that exist. When the number of men passing the examination exceeds the number of vacancies, some system must be used to determine which men may be advanced and which may not. The system used is the "final multiple" and is a combination of three types of advancement systems.

Merit rating system
Personnel testing system
Longevity, or seniority system

The Navy's system provides credit for performance, knowledge, and seniority, and, while it cannot guarantee that any one person will be advanced, it does guarantee that all men within a particular rating will have equal advancement opportunity.

The following factors are considered in computing the final multiple:

Factor	Maximum Credit
Examination score	80
Performance factor (Performance evaluation)	50
Length of service (years x 1)	20
Service in pay grade (years x 2)	20
Medals and awards	15
	185

All of the above information (except the examination score) is submitted to the Naval Examining Center with your examination answer sheet. After grading, the examination scores, for those passing, are added to the other factors to arrive at the final multiple. A precedence list, which is based on final multiples, is then prepared for each pay grade within each rating. Advancement authorizations are then issued, beginning at the top of the list, for the number of men needed to fill the existing vacancies.

KEEPING CURRENT ON ADVANCEMENT

Remember that the requirements for advancement may change from time to time. Check with

your division officer or with your training officer to be sure you have the most recent requirements when you are preparing for advancement and when you are helping lower rated men to prepare for advancement.

To prepare for advancement, you need to be familiar with (1) the military requirements and the occupational qualifications given in the Manual of Qualifications for Advancement, NavPers 18068-B (with changes); (2) the Record of Practical Factors, NavPers 1414/1; (3) appropriate Rate Training Manuals; and (4) any other material that may be required or recommended in the current edition of Training Publications for Advancement, NavPers 10052. These materials are discussed later in the section of this chapter that deals with sources of information.

SCOPE OF THIS TRAINING MANUAL

Before studying any book, it is a good idea to know the purpose and the scope of the book. Here are some things you should know about this training manual:

- It is designed to give you information on the occupational qualifications for advancement to BU1 and BUC.

- It must be satisfactorily completed before you can advance to BU1 or BUC, whether you are in the regular Navy or in the Naval Reserve.

- It is NOT designed to give you information on the military requirements for advancement to PO1 or CPO. Rate Training Manuals that are specially prepared to give information on the military requirements are discussed in the section of this chapter that deals with sources of information.

- It is NOT designed to give you information that is related primarily to the qualifications for advancement to BU3 and BU2. Such information is given in Builder 3 & 2, NavPers 10648-E.

- The occupational Builder qualifications that were used as a guide in the preparation of this training manual were those promulgated in the Manual of Qualifications for Advancement, NavPers 18068-B, change 3. Therefore, changes in the Builder qualifications occurring after this change may not be reflected in the information given in this training manual. Since your major purpose in studying this training manual is to meet the qualifications for advancement to BU1 or BUC, it is important for you to obtain and study a set of the most recent Builder qualifications.

- This training manual includes information that is related to both the KNOWLEDGE FACTORS and the PRACTICAL FACTORS of the qualifications for advancement to BU1 and BUC. However, no training manual can take the place of actual on-the-job experience for developing skill in the practical factors. The training manual can help you understand some of the whys and wherefores, but you must combine knowledge with practical experience before you can develop the required skills. The Record of Practical Factors, NavPers 1414/1, should be utilized in conjunction with this training manual whenever possible.

- Chapters 2 through 13 of this training manual deal with the occupational subject matter of the Builder rating. Before studying these chapters, study the table of contents and note the arrangement of information. Information can be organized and presented in many different ways. You will find it helpful to get an overall view of the organization of this training manual before you start to study it.

SOURCES OF INFORMATION

It is very important for you to have an extensive knowledge of the references to consult for detailed, authoritative, up-to-date information on all subjects related to the military requirements and to the occupational qualifications of the Builder rating.

Some of the publications discussed here are subject to change or revision from time to time—some at regular intervals, others as the need arises. When using any publication that is subject to change or revision, be sure you have the latest edition. When using any publication that is kept current by means of changes, be sure you have a copy in which all official changes have been entered.

BUPERS PUBLICATIONS

The BuPers publications described here include some which are absolutely essential for anyone seeking advancement and some which, although not essential, are extremely helpful.

THE QUALS MANUAL.—The Manual of Qualifications for Advancement, NavPers 18068-B (with changes), gives the minimum requirements for advancement to each rate within each rating. The Quals Manual lists the military requirements which apply to all ratings and the occupational qualifications that are specific to each rating.

The Quals Manual is kept current by means of numbered changes. These changes are issued more frequently than most Rate Training Manuals can be revised; therefore, the training manuals cannot always reflect the latest qualifications for advancement. When preparing for advancement, you should always check the LATEST Quals Manual and the LATEST changes to be sure that you know the current requirements for advancement.

When studying the qualifications for advancement, remember these three things:

1. The quals are the MINIMUM requirements for advancement to each rate within each rating. If you study more than the required minimum, you will of course have a great advantage when you take the written examination for advancement.

2. Each qual has a designated pay grade—E-4, E-5, E-6, E-7, E-8, or E-9. You are responsible for meeting all quals specified for advancement to the pay grade to which you are seeking advancement AND all quals specified for lower pay grades.

3. The written examinations for advancement to E-6 and above contain questions relating to the practical factors and the knowledge factors of BOTH military/leadership requirements and occupational qualifications. Personnel preparing for advancement to E-4 or E-5 must pass a separate military/leadership examination prior to participation in the Navy-wide occupational examination. The military/leadership examinations for the E-4 and E-5 levels are given according to a schedule prescribed by the commanding officer. Candidates are required to pass the applicable military/leadership examination only once.

RECORD OF PRACTICAL FACTORS.—A special form known as the Record of Practical Factors, NavPers 1414/1, is used to record the satisfactory completion of the practical factors, both military and occupational, listed in the Quals Manual. Either this form or its predecessor, NavPers 760, is available for each rating. The old form will continue to be used until supplies are exhausted. Whenever a person demonstrates his ability to perform a practical factor, appropriate entries must be made in the DATE and INITIALS column. As a BU1 or BUC, you will often be required to check the practical factor performance of lower rated men and to report the results to your supervising officer. To facilitate record keeping, group records of practical factors are often maintained by each activity. Entries from the group records must, of course, be transferred to each individual's Record of Practical Factors at appropriate intervals.

As changes are made periodically to the Quals Manual, new forms of NavPers 1414/1 are provided when necessary. Extra space is allowed on the Record of Practical Factors for entering additional practical factors as they are published in changes to the Quals Manual. The Record of Practical Factors also provides space for recording demonstrated proficiency in skills which are within the general scope of the rating but which are not identified as minimum qualifications for advancement. Keep this in mind when you are training and supervising lower rated personnel. If a man demonstrates proficiency in some skill which is not listed in the Builder quals but which falls within the general scope of the rating, report this fact to the supervising officer so that an appropriate entry can be made.

The Record of Practical Factors should be kept in each man's service record and should be forwarded with the service record to the next duty station. Each man should also keep a copy of the record for his own use.

NAVPERS 10052.—Training Publications for Advancement, NavPers 10052, is a very important publication for anyone preparing for advancement. This publication lists required and recommended Rate Training Manuals and other reference material to be used by personnel working for advancement. NavPers 10052 is revised and issued once each year by the Bureau of Naval Personnel. Each revised edition is identified by a letter following the NavPers number. When using this publication, be SURE you have the most recent edition.

The required and recommended references are listed by rate level in NavPers 10052. It is important to remember that you are responsible for all references at lower rate levels, as well as those listed for the rate to which you are seeking advancement.

Rate Training Manuals that are marked with an asterisk (*) in NavPers 10052 are MANDA-

TORY at the indicated rate levels. A mandatory training manual may be completed by (1) passing the appropriate Enlisted Correspondence Course based on the mandatory training manual, (2) passing locally prepared tests based on the information given in the mandatory training manual, or (3) in some cases, successfully completing an appropriate Navy school.

It is important to notice that all references, whether mandatory or recommended, listed in NavPers 10052 may be used as source material for the written examinations, at the appropriate rate levels.

RATE TRAINING MANUALS.—Rate Training Manuals are written for the specific purpose of helping personnel prepare for advancement. Some manuals are general in nature and are intended for use by more than one rating; others (such as this one) are specific to the particular rating.

Rate Training Manuals are revised from time to time to bring them up to date. The revision of a Rate Training Manual is identified by a letter following the NavPers number. You can tell whether a Rate Training Manual is the latest edition by checking the NavPers number and the letter following the number in the most recent edition of the List of Training Manuals and Correspondence Courses, NavPers 10061 (revised).

There are three Rate Training Manuals that are specially prepared to present information on the military requirements for advancement. These manuals are:

Basic Military Requirements, NavPers 10054 (current edition).

Military Requirements for Petty Officer 3 & 2, NavPers 10056 (current edition).

Military Requirements for Petty Officer 1 & C, NavPers 10057 (current edition).

Each of the military requirements manuals is mandatory at the indicated rate levels. In addition to giving information on the military requirements, these three manuals give a good deal of useful information on the enlisted rating structure; how to prepare for advancement; how to supervise, train, and lead other men; and how to meet your increasing responsibilities as you advance.

Some of the Rate Training Manuals that may be useful to you when you are preparing to meet the occupational qualifications for advancement to BU1 or BUC are discussed briefly in the following paragraphs.

Basic Handtools, NavPers 10085-A. Although this training manual is not specifically required for advancement in the Builder rating, you will find that it contains a good deal of useful information on the care and use of various types of handtools and portable power tools commonly used in the Navy.

Blueprint Reading and Sketching, NavPers 10077-B. This training manual contains information that may be of value to you as you prepare for advancement to BU1 and BUC.

Mathematics, Vol. 1, NavPers 10069-B, and Mathematics, Vol. 2, NavPers 10071-A. These two training manuals may be helpful if you need to brush up on your mathematics. Volume 1, in particular, contains basic information that is needed for using formulas and for making simple computations. The information contained in Volume 2 is more advanced than you will need for most purposes, but you may occasionally find it helpful.

Builder 3 & 2, NavPers 10648-E. Satisfactory completion of this training manual is required for advancement to BU3 and BU2. If you have met this requirement by satisfactorily completing an earlier edition of Builder 3 & 2, you should at least glance through the -E revision of the training manual. Much of the information given in this edition of Builder 1 & C is based on the assumption that you are familiar with the contents of Builder 3 & 2, NavPers 10648-E.

Rate Training Manuals prepared for other Group VIII (Construction) ratings are often a useful source of information. Reference to these training manuals will increase your knowledge of the duties and skills of other men in the Construction ratings. The training manuals prepared for Construction Electricians and Utilitiesmen are likely to be of particular interest to you, since nearly every building whose construction you supervise must be so constructed as to permit the installation of electrical and utility fixtures.

CORRESPONDENCE COURSES.—Most Rate Training Manuals and Officer Texts are used as the basis for correspondence courses. Completion of a mandatory training manual can be accomplished by passing the correspondence course that is based on the training manual. You will find it helpful to take other correspondence courses, as well as those that are based on mandatory training manuals. Taking a correspondence course helps you to master

the information given in the training manual or text and also gives you a pretty good idea of how much you have learned from studying the manual. Both enlisted and officer correspondence courses are listed in the List of Training Manuals and Correspondence Courses, NavPers 10061 (revised).

NAVFAC PUBLICATIONS

A number of publications issued by the Naval Facilities Engineering Command (NAVFAC) which will be of interest to personnel in the Group VIII ratings are listed in the Index of Naval Facilities Engineering Command Publications, NAVFAC P-349 (updated semiannually). A publications program is one of the principal communications media used by NAVFAC to provide a ready reference of current technical and administrative data for use by its subordinate units. NAVFAC publications are listed in alphabetical and numerical order in NAVFAC P-349; copies of NAVFAC P-349 may be obtained through proper channels from the Naval Supply Depot, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120.

NAVFAC publications that the BU will find useful include various operation and maintenance manuals, commonly referred to as MOs. You will be especially concerned with those MOs dealing with such subjects as roofing, painting, waterfront facilities, and structures. MOs provide information that will be beneficial to you in the maintenance of buildings and structures found at naval shore activities. Some of the design manuals, often called DMs, published by NAVFAC may also contain information of interest to the BU. The DMs present criteria for use in the design of various types of facilities under the cognizance of NAVFAC.

TRAINING FILMS

Training films available to naval personnel are a valuable source of supplementary information on many technical subjects. Films on various subjects that may be of interest are listed in the United States Navy Film Catalog, NAVWEPS 10-1-777, published in 1966. This catalog is now listed in the NavSup Forms and Publications Catalog, NavSup 2002, as NavAir 10-1-777. Beginning in 1967, Supplements to the Film Catalog carry the number NavAir 10-1-777.

When selecting a film, note its date of issue listed in the film catalog. As you know, procedures sometimes change rapidly. Thus some films become obsolete rapidly. If a film is obsolete only in part, it may sometimes be shown effectively if before or during its showing you carefully point out to trainees the procedures that have changed. For this reason, if you are showing a film to train other personnel, take a look at it in advance if possible so that you may spot material that may have become obsolete and verify current procedures by looking them up in the appropriate sources before the formal showing.

CHAPTER 2

PLANNING AND ESTIMATING

The Builder supervisor can expect planning and estimating to involve his job to some extent during most every working day. This chapter provides some hints on planning that will be useful to you in planning jobs to be done in the shop or field. We will take up various types of estimates that may concern you in your work. We will explain the purpose of specific types of estimates and different entries on these estimates. To be a good planner and estimator, the Builder must know and understand technical drawings. As part of this instruction, information is provided on both technical drawings and technical sketching.

HINTS ON PLANNING

Planning is the process of determining requirements and devising and developing methods and schemes of action for construction of a project. In addition to day-to-day planning, the following primary matters should be considered in construction planning: work element estimates, material estimates, equipment estimates, manpower estimates, material delivery and stowage. These considerations are more or less dependent upon each other and all are taken into account in any well-planned project. The success of any project depends to a great extent upon the amount of detail and the care taken in planning it.

Proper planning saves time and money for the Navy, and makes the work easier and more pleasant for your whole group. It can eliminate friction, jealousy, and confusion, and can free you from many of the details of the work, thus giving you time to carry out other important duties. Proper planning expedites the work and eliminates "bottlenecking," (remember that the neck of the bottle is always at its top), and, most important to you personally, it makes your job easier.

As the petty officer in charge, you are responsible for the time of your men, as well as for your own time. You must plan so that your men will be kept busy doing constructive work. This will be to your convenience, and a point to remember is: PLAN AHEAD. Having the men stand around idle each morning while you plan obviously would be a waste of manpower. At the close of each day, you should confirm planning for the next work day. In doing so, carefully consider factors that have a bearing on the availability and use of manpower, equipment, and supplies. For effective planning, you may need answers to various questions, such as those listed below.

MANPOWER. Who is to do what? How is it to be done? When is it to be finished? Knowing that idleness may breed discontent, have you arranged to have another job ready for starting as soon as the first one is finished? Is every man fully utilized?

EQUIPMENT. Are all necessary items of equipment and tools on hand to do the job? Is safety equipment on hand?

SUPPLIES. Are all necessary supplies on hand to start the job? If not, who should take action?

Have a definite work schedule and inspection plan. Set up realistic goals or quotas for the day. Have a definite plan for personally checking at intervals to see that the work is being accomplished and that the goals will be achieved. Spot-check for accuracy, workmanship, and the need for training.

Builders must be trained to do a variety of jobs by means of the rotation method, on-the-job training, or classroom work; allow time for this in your planning for a job. Time must also be allowed for handling personnel problems, records, and military duties. A supervisor must allow time for reports and other paperwork which is necessary for the control of men and materials under his charge.

Until a petty officer learns to delegate work properly, he can never be much of a success. In delegating authority, be sure that the man concerned has the training and information necessary to carry out the work. If you find that he cannot do the job required, he may have to be retrained. Remember, you can delegate your authority, within reason, to subordinates; but you cannot delegate your responsibility for the final product.

ESTIMATING FOR CONSTRUCTION

Estimating is the act of determining the size of the job, the kind of work to be performed, and determining the quantities of work elements, materials, labor and equipment needed to perform this work. The lists of these quantities are called estimates. Estimating is an important part of planning for jobs and/or projects. If you like working with figures, the preparation of estimates should be interesting work. In addition to a knowledge of arithmetic, however, an estimator should possess a number of other qualifications, some of which are noted below.

A good Seabee estimator should be able to mentally picture the separate operations of the job as the work will progress through the various stages of construction. He should have previous construction experience and must be able to do careful and accurate work free of errors. A Seabee estimator should possess ability to use good judgment when determining what effect numerous factors and conditions will have on construction of the project and what allowances should be made for each of them. He should have available to him information about materials, equipment, and labor that is required to perform various types of work under conditions encountered in accomplishing Seabee construction projects. Collection of such information on construction performance is part of the job of estimating. Reference information of this kind may change from time to time, and therefore should be revised frequently. An estimator, working either by himself or as a member of a team, may often be required to plan construction and prepare estimates for other construction ratings as well as his own. So, in addition to knowing his own specialty, a good estimator should have a working knowledge of other branches of construction for which he will have to draw up estimates.

At this point, let us remind you that various procedures are used in estimating for construction work, and those described here are suggested procedures rather than standard procedures. You must use judgment as to when the procedures can be applied effectively; and, in some cases you may want to make revisions in a procedure to make it more suitable to the particular project being estimated.

USE OF DRAWINGS AND SPECIFICATIONS

Information provided on drawings is a main basis for measuring quantities of work elements and materials. Accurate estimating requires a thorough examination of the drawings. All notes and references should be read carefully and all detail and reference drawings should be examined. Dimensions shown on drawings and/or figured dimensions should be used in preference to scaled dimensions. If it becomes necessary to scale dimensions on drawings, a scale rule should be used and the graphic scale on the drawings should be checked for expansion or shrinkage. When there is disagreement between the plans, elevations, and details, the detail drawing should normally be followed unless it is obviously wrong.

Drawings are supplemented by WRITTEN SPECIFICATIONS, commonly referred to as "Specs." Specifications give detailed instructions regarding materials and methods of work. They cover various factors relating to the job, such as general conditions, scope of work, quality of materials, standards of workmanship, and protection of finished work. The drawings and specifications are inseparable; the drawings indicate what the specifications cannot, and the specifications indicate what the drawings are unable to portray.

FEDERAL SPECIFICATIONS cover the characteristics of materials and supplies used jointly by the Navy, with other Government departments.

MILITARY SPECIFICATIONS are those that have been developed and adopted for use by the Department of Defense. They are identified by "JAN" or "MIL" preceding the first letter and serial number. They were formerly called joint ARMY and Navy Specifications, or "JAN." As they are revised the JAN is being replaced by MIL, but the serial number itself remains the same.

NAVFAC SPECIFICATIONS (formerly Yards and Docks specifications) are prepared by the Naval Facilities Engineering Command and set

forth standards of construction. They must conform to specifications set forth by Federal or military procurements. Among NAVFAC specifications that may concern you as a Builder are:

4Yf	Portland Cement Concrete
7Yj	Roofing and Sheet Metal Work
10Ye	Metal Windows (Steel and Aluminum)
13Yh	Concrete Construction.

On many jobs, you will be furnished written specifications, often called PROJECT SPECIFICATIONS. They apply to the particular job at hand and often contain information on instructions taken from Federal Specifications, Military Specifications, and NAVFAC Specifications.

The specifications should be used together with the drawings when making quantity estimates. When there is disagreement between the specifications and the drawings, the specifications should normally be followed. If in doubt, consult the OICC, Operations, or PW officer for a decision. The estimator should become thoroughly familiar with all the requirements stated in the specifications. Some estimators will have to read the specifications more than once in order to fix these requirements in their minds. Notes made while reading the specifications will prove helpful when examining the drawings. These notes should list items of work or materials which are unusual, items not familiar to the estimator, and reminders for use during examination of the plans.

NEED FOR ACCURACY

Quantity estimates are used as a basis for purchasing materials and for determining equipment and manpower requirements. They are also used in scheduling progress, which provides the basis for scheduling material deliveries, equipment and manpower. In view of the widespread use, you can see that accuracy in preparing quantity estimates is very important. To help ensure accuracy, quantity estimates should be checked in a manner that will eliminate as many errors as possible. One of the best ways to check a quantity estimate is to have another person make an independent estimate and then compare the two estimates after both are completed.

WORK ELEMENT ESTIMATES

A work element estimate is a listing of the quantities of each work element (such as board feet of lumber) required to construct a given project. Work element estimates are prepared by computing the quantities of the various items of work shown or referenced by notes on the drawings and described in the specifications. You may sometimes hear work element estimates called Quantity Surveys or Quantity Takeoffs. They are used in scheduling progress, which provides the basis for scheduling material deliveries, equipment and manpower. Errors in work element estimates can multiply many times through their use in the preparation of these other estimates and schedules.

An estimator should have a good general knowledge of the project to be constructed, before performing any actual takeoff of quantities. This knowledge can be obtained by a general study of the drawings, reading the specifications, and examining all available information about the project site and local conditions. After he has become familiar with the project, the estimator is ready to begin measuring and recording quantities of materials for the work elements.

The normal practice when measuring quantities is to begin by measuring work elements on the foundation and footing plan and to proceed through the basement and each succeeding floor plan of the architectural and structural drawings. All reference and detail drawings that refer to a particular plan are examined and worked in conjunction with that plan. After examination of the plans, the elevations and then the details are examined one by one, and all materials not previously taken off are measured and recorded. Often concrete, reinforcing, and structural features are shown on drawings separate from the architectural features. When this is done, it is best to work the concrete and reinforcing drawings first, followed by the architectural drawings. After completing the architectural and structural drawings, the mechanical, and then the electrical drawings are worked, and these are followed by any available specialty, civil, or shop drawings.

When measuring quantities on a drawing, it is better to begin at one side and work towards the opposite side, marking with a colored pencil the particular work as it is measured and recorded. Work such as concrete, reinforcing, and similar items can be marked with a simple check (✓), but items such as conduit and piping should be marked by tracing over the part measured with a colored pencil. The colored marks not only show the estimator what has been taken off, thus preventing duplication, but provide a means of checking a drawing for omissions.

As each work element is measured, the information is recorded and computations are shown on a worksheet. Figure 2-1 illustrates the type of information shown on a typical work element estimate worksheet. The heading of each worksheet should show the following: that it is a work element estimate worksheet, the worksheet number, estimator's name, date of takeoff, checker's name, date checked, battalion number, deployment location, year, project number, and project description.

A summary of work element quantities is prepared by transferring the totals on the worksheets to a summary sheet, which becomes the work element estimate. Work elements are arranged in the same sequence as they appear in the standard work element list so they will be in correct sequence for reporting or recording on work schedules. This summary sheet has the same information in the heading as the worksheet, except that it is shown as a work element estimate summary sheet. The body of the summary sheet shows the description and quantity of the work elements. If decisions have been made as to how the work will be accomplished, this is indicated by the entry—for example, excavation is entered as machine excavation and backfill as machine backfill. A typical work element estimate summary sheet is illustrated in figure 2-2.

Before proceeding, note that the forms shown in figures 2-1 through 2-4 of this discussion illustrate the minimum amount of information which should appear on such forms, and should NOT be considered as standard worksheets. Some estimators may wish to record additional information, or they may desire to record their work in a different manner. A main object to keep in mind is that the recording is to be detailed in such manner that anyone reviewing the estimate can understand what was taken off and how computations were made. If this procedure is followed, an independent check can be made without questioning the estimator as to how he arrived at any quantity in the estimate.

MATERIAL ESTIMATES

A material estimate is a listing and description of the various materials and the quantities required to construct a given project. Information for preparing material estimates is obtained from drawings and specifications. A material estimate is sometimes referred to as a Materials Takeoff.

Material estimates are used as a basis for construction material procurement, and also as a check to determine if sufficient materials are available to construct or to complete a project. For example, the operations officer might have some doubts about availability of materials to complete a certain project, so an estimate is prepared listing quantities of materials that will be required to complete the project. This estimate is compared with the stock of materials on hand to determine any shortage.

The following is a suggested procedure for preparation of a material estimate. First, obtain the work element quantity, which is usually done by referring to the work element estimate. Convert this into quantities of materials required to perform the work. (Conversion units obtained from tables supplied by Naval Schools, Construction courses should be used whenever possible.) This conversion should be done on a worksheet which will record how each material quantity was obtained. A typical material estimate worksheet is shown in figure 2-3. It is important that worksheets be sufficiently detailed to be self-explanatory, so that anyone examining them can determine how quantities were computed without consulting the estimator. Sometimes if desired, a sketch furnished will explain how the estimator planned the takeoff. After computing material quantities on the worksheets, enter them on recap sheets with like materials for a project grouped together and totaled. Allowances for waste and loss are added after the quantities are totaled. There are some items, such as reinforcing tie wire and nails, which are computed using a material quantity rather than a work element quantity. These computations should appear at the end of the worksheets, using total quantities obtained from the recap worksheet. Notes should be made on the worksheet to remind the estimator that these items are to be compared using total quantities from recap sheets. The recap worksheet becomes the material estimate. A sample of a typical recap worksheet is shown in figure 2-4.

During construction there is a certain amount of material wasted due to cutting, fitting, and handling. For example, lumber comes in standard lengths which seldom can be used without cutting and fitting. Sometimes the pieces of lumber cut off can be used, but more often it goes into the scrap pile. Allowance must be made in the materials estimate for this waste. There is also the possibility of loss due to pilferage, cumshaw work, and weather. Waste and loss

WORK ELEMENT ESTIMATE
WORKSHEET

SHEET NO. 2 OF 6
ESTIMATED BY Kemp DATE 7-7-6-
CHECKED BY Bigby DATE 8-10-6-

MCB 3 LOCATION Saipan YEAR 196-
PROJECT 08 DESCRIPTION Staging-out Warehouse

WORK ELEMENT	LOCATION	MEASUREMENT AND COMPUTATION	QUANTITY
Footings and foundations (continued)			
Concrete	Est. col. ftgs.	46 ftgs. 8'-3" sq x 1'-9" deep 46 x 8.25 x 8.25 x 1.75	5479 CF
	Int. col. ftgs.	38 ftgs. 7'-3" sq. x 1'-9" deep 38 x 7.25 x 7.25 x 1.75	3495 CF
	Int. col. piers	38 piers 2'4" sq. x 4'6" high 38 x 2.33 x 2.33 x 4.5	928 CF
	Grade beam sides	2 sides 402' x 4" lg. 14" wide, 4'6" hi. 2 x 402.33 x 1.17 x 4.5	4237 CF
	Grade beam ends	2 ends 100'-3" lg, 14" wide 4'6" hi 2 x 100.25 x 1.17 x 4.5	1056 CF
		Subtotal	15,195 CF

87.1

Figure 2-1.—Work element estimate worksheet.

SHEET 1 OF 1

ESTIMATED BY Kemp DATE 6-22-6-

CHECKED BY Bixby DATE 8-24-6-

WORK ELEMENT ESTIMATE
SUMMARY SHEET

MCB 10 LOCATION Saipan YEAR 196-

PROJECT 08 DESCRIPTION Staging-Out Warehouse

WORK ELEMENT	QUANTITY
Footings and foundations	
Machine excavation	1860 CY
Machine backfill	1277 CY
Hand compaction	1277 CY
Spread excess earth-machine	583 CY
Form and strip	11,083 SFCS
Place reinf. steel	34.6 Tons
Place finish & cure concrete	582.8 CY

145.4

Figure 2-2.—Work element estimate summary sheet.

MATERIAL ESTIMATE

WORKSHEET

SHEET NO. 2 OF 4

ESTIMATED BY Kemp DATE 8-16-6—

CHECKED BY Bigby DATE 8-24-6—

MCB 9 LOCATION Bermuda YEAR 196—

PROJECT 01 DESCRIPTION Naval Stores Warehouse

DESCRIPTION	WORK ELEMENT QUANTITY	CONVERSION UNIT	QUANTITY REQUIRED	REMARKS
Concrete Walls—				62 CY
Forms-50% reuse	5000 SFCS			
Plywood-3/4"	do	.5	2500 SF	Fir, form grade
2×4	do	1.25	6250 LF	S4S #2 YP or equal
Form oil	do	1 gal./200 SF	25 gallons	
Snapties 8" wall	do	.125	625 each	
Snap tie wedges	do	.125	625 each	
Nails (see	sheet	4 of 4)		
Reinforcing—				
Reinf. bars	12252 lbs.		100 #4 × 40' 200 #5 × 40' 21 #6 × 40'	
Tie wire (see	sheet	4 of 4)		
Concrete —	62 CY			6½ pack
Portland Cement	do	6.5	403 sks	
Fine aggregate	do	.6	37 CY	
Coarse aggregate	do	1	62 CY	
Curing Compound	5200 SF	1 gal./200 SF	26 gallons	
Finish. Portland cement	5000 SF	2 sks/1000 SF	10 sks.	
Finish-Fine aggregate	do	.0003	2 CY	

87.2

Figure 2-3.—Material estimate worksheet.

MATERIAL ESTIMATE

RECAP SHEET

SHEET NO. 3 OF 5

ESTIMATED BY Kemp DATE 8-16-6—

CHECKED BY Bixby DATE 8-24-6—

MCB 9 LOCATION Bermuda YEAR 196—

PROJECT 01 DESCRIPTION Naval Stores Warehouse

DESCRIPTION	QUANTITY	WASTE & LOSS FACTOR	WASTE & LOSS	QUANTITY TO PROCURE	REMARKS
#6 Reinf. bars 40' long	—				
Walls	21 pc				
Roof slab	24 pc				
	45 pc	10%	5	50 pc.	2000 LF 3000 lbs.
Portland cement —					
Slabs on grade	450 SKS				
Walls	403 SKS				
Finishing walls	10 SKS				
Roof slab	520 SKS				
Finishing roof	8 SKS				
	1391 SKS	10%	139	1530 SKS	
Fine aggregate —					
Slabs on grade	45 CY				
Walls	37 CY				
Finishing walls	2 CY				
Roof slab	48 CY				

87.3

Figure 2-4.—Material estimate recap sheet.

factors as supplied by Naval Schools, Construction are based on a large number of jobs performed under varied conditions and at many different locations. An estimator has specific information about the job and is in a position to determine if conditions warrant increasing the waste and loss factor normally used for any material item. And, he should not hesitate to vary this waste and loss factor when job conditions indicate that normal factors are too low.

Formwork Material Estimate

The first consideration in the formwork estimating is the number of square feet of contact surface (sfcs) in the formwork—meaning, the area of sheathing which will be in surface contact with the concrete. Suppose you want to estimate the foundation of a building 30 ft long, 20 ft wide, and 5 ft high, and with walls to be 8" thick. The GROSS surface contact area will come to 4(5 x 30) + 4(5 x 20), or 1,000 sq ft. From this you would deduct the areas of any large openings, such as door openings; the remainder would be the NET surface contact area. We'll assume there are no openings: therefore, there are 1,000 sq ft of contact area.

Suppose the only plywood available is in 4 ft x 8 ft sheets. Placed long-way horizontally, one sheet will cover a wall length of 8 ft. Therefore. another sheet will have to be ripped to obtain the proper height of 5 ft. The wall length to be covered is 2(30) + 2(20), or 100 ft. It will take five sheets to cover the long wall properly, and four sheets to cover the short side; therefore, 18 sheets will be needed to cover the entire 100 ft.

There will be two 2" x 4" x 5' studs for every 16 in. (1.33 ft) of wall length. For each 30-ft wall, then, the number of studs will be the value of x in the equation 2:1.33::x:30, or 46, plus two at the wall end which don't get into the equation, for a total of 48. For each 20-ft wall the number will be the value of x in the equation 2:1.33::x:20, or 30, and again plus two, for a total of 32. The total number of studs, then, will be 2(48) + 2(32), or 160.

Horizontal and angle braces are to be attached to studs and spaced 4' 0" O.C. This means that these braces will be located at every third pair of studs, which means that 80/3, or 27 pairs of studs will have braces. There are two angle braces and two horizontal braces at each of these 27 pairs; therefore, the number of items in each of these categories is 2 (27), or 54. For each of these 27 pairs of studs there will be two 2" x 4" x 2' 0" stakes, making 2 (27), or 54 stakes. Snap ties are likewise spaced 4' 0" O.C.; therefore, there will be two sets of 2 ties (or a total of 4 ties, with holders), repeated 27 times in the formwork. The total number of ties, then, will be 4(27), or 108 ties. For each of the 27 pairs of studs there is a 1" x 2" x 1'4" wooden tie to hold the anchor bolts.

The length of a wale for the outside form studs will be the same as the length of the wall—that is, either 30 or 20 ft. The length of a wale for the inside form studs will equal the length of the wall minus twice the thickness of the wall, or minus 2 (8 in.), or 16 in., or 1 ft 4 inches. Therefore, a length of 2 x 4 for an inside 30-ft wall would measure 28 ft 8 in.; a length for an inside 20-ft wall would measure 18 ft 8 in. You would need 16 of the 28 ft 8 in. lengths and 16 of the 18 ft 8 in. lengths. Likewise, for the outside wales, you would need 16 of the 30 ft lengths and 16 of the 20 ft lengths.

For plywood form sheathing you need 1 gal of form oil for every 200 sq ft of contact surface. A value like this, expressed as 1 gal/200 sfcs, is called a CONVERSION UNIT. In this case you have 1,000 sq ft of contact surface; therefore, you will need 5 gals of form oil.

Nail quantities for formwork are usually figured on the basis of conversion units which give quantities in pounds required for every 1,000 sq ft of contact surface, the nails commonly used being 6d, 8d, 16d, and 20d common. Conversion units given in the Seabee Planner's and Estimator's Handbook, NavDocks P-405, are 6, 4, 6, an 2 lbs respectively per 1,000 sfcs. You have 1,000 sfcs here; therefore, you will need 6 lbs of 6d, 4 lbs of 8d, 6 lbs of 16d, and 2 lbs of 20d. Remember, that all falsework and braces require duplex (double-headed) nails, which facilitate removal.

You can now enter these values on a bill of materials for formwork as shown in figure 2-5. If you are ordering your lumber by the linear foot, you can easily determine the total linear footage of 2 x 4 and 1 x 2 from the bill of materials. The board measure values make it possible for the lumber costs to be calculated on the basis of current BF prices.

Concrete Ingredient Estimate

For a 5-ft high 8-in. thick concrete foundation wall for a 30 ft x 20 ft rectangular building you will need, if the wall contains no openings, 2(30 x 5 x 8/12) + 2(20 x 5 x 8/12), or 334 cu ft of concrete. Suppose the specifications call for a dry weight mixture with a W:C ratio of 6 gals per sack and ingredient proportions of 1 cement: 2.2 sand: 3.7 coarse aggregate, with permissible slump at about 4 in. A table of yield shows that for a 1-sack batch

BILL NO. 1 - FOR FORMWORK

ITEM	QUANTITY	UNIT	SIZE	LENGTH	FT BD MEAS	DESCRIPTION
1	50	sheets	3/4"x4'0"	8'0"		plywood sheathing
2	160	pc	2"x 4"	6'0"	640	studs
3	54	pc	2"x 4"	4' 3"	153	horizontal braces
4	54	pc	2"x 4"	5' 8"	204	angle braces
5	54	pc	2"x 4"	2' 0"	72	stakes
6	16	pc	2"x 4"	28' 8"	304	inside long wall wales
7	16	pc	2"x 4"	18' 8"	195	inside short wall wales
8	16	pc	2"x 4"	30'0"	320	outside long wall wales
9	16	pc	2"x 4"	20'0"	214	outside short wall wales
10	27	pc	1"x2"	1'4"	6	wooden ties
11	216	ea				snap ties w/holders
12	5	gals				form oil
NAILS						
	6	lbs	6 d			common
	4	lbs	8 d			"
	3	lbs	16 d			"
	2	lbs	20 d			"

117.20

Figure 2-5.—Bill of materials for formwork.

with these ingredient proportions the approximate yield is 4.64 cu ft of concrete. Therefore, the number of 1-sack batches required for 334 cu ft will equal the value of x in the equation 1:4.64::x:334, or 72. This means, in the first instance, 72 sacks of cement.

A sack of cement weighs 94 lbs. The weight of the sand in a 1-sack batch, then, will be 94 x 2.2, or 207 lbs. For 72 1-sack batches the weight of the sand will be 72 x 207, or 14,904 lbs. Ordinary sand weighs about 110 lbs per cu ft; therefore, you will need 14,904/110, or 136 cu ft of sand. You generally order sand by the cu yd; in this case you will need 136/27, or 5.1 cu yd.

The weight of the coarse aggregate in a 1-sack batch will be 94 x 3.7, or 348 lbs. For 72 1-sack batches you will need 72 x 348, or 25,056 lbs. Suppose the maximum size of coarse is specified at 1-1/2 in. Coarse aggregate of this size weighs about 100 lbs per cu ft; therefore, you will need 25,056/100, or 251 cu ft of coarse. This comes to 251/27, or about 9.5 cu yd.

You would enter these quantities in a bill of materials for concrete as shown in figure 2-6.

Frame Material Estimate

Suppose the drawings show a platform-frame structure with a single 2 x 6 sill. The total length of the sill will be 2 x 20 + 2 x 30, or 100 ft. Suppose sill stock will be ordered in 12-ft lengths. You will need five 12-ft pieces to make up the longer wall lengths, and four 12-ft pieces to make up the shorter wall. Therefore, the total number of 12-ft pieces needed for the sill will be 5 + 4 = 9, or 108 ft. You would enter this quantity in a bill of materials for frame as shown in figure 2-7. Assuming the 12-ft pieces are

BILL NO. 2 - FOR CONCRETE

ITEM	QUANTITY	UNIT	SIZE	LENGTH	FT BD MEAS	DESCRIPTION
1	72	SACK				cement, foundation walls
2	5.1	CU YD				sand, foundation walls
3	9.5	CU YD				2" aggregate, foundation walls

117.21
Figure 2-6.—Bill of materials for concrete.

common stock, you should have approximately 10 ft left over. The additional 2 ft will occur because the shorter sill will butt against the longer one.

Suppose the drawings show the ground floor joists to be 2 x 10's, spaced 16 in. O.C., and running with the shorter (20-ft) wall lengths. The length of a ground-floor common joist, then, will be 20 ft minus twice the thickness of the wall sheathing and twice the thickness of a header joist. Say the wall sheathing will consist of 1 x 8's with an actual thickness of 3/4 inch. A 2 x 10 header joist has an actual thickness of 1-5/8 inch. Therefore, the length of a common joist will be 20 ft minus the sum of 2 x 3/4 in. and 2 x 1-5/8 in. or minus 4-3/4 in., or 19 ft 7-1/4 in.

The common joists will be spaced 16 in., or 1.33 ft. O.C. The total number of common joists needed will equal 1 (for the first joist) plus the value of x in the equation 1:1.33::x:30, or 1 + 23, or 24. You would enter these determined values in the bill of materials as shown in fig. 2-7. Note that no allowance has been made for possible floor openings not spanned by joists. Some estimators ignore openings, figuring that sections cut out of joists for openings will cover requirements for headers in openings and other needed shorter sections of joist stock. However, other estimators take openings into account. Even if you don't take openings into account, you should add one to the common joist total for every full length trimmer or double joist shown or indicated in the drawings.

The length of header joists on each 30-ft wall will equal the length of the wall minus

BILL NO. 3 - FOR FRAME

ITEM	QUANTITY	UNIT	SIZE	LENGTH	FT BD MEAS	DESCRIPTION
1	9	pc	2"x6"	12' 0"	108	sill
2	24	pc	2"x10"	19' 7¼"	786	ground floor common joist
3	5	pc	2"x10"	12' 0"	100	" " header "
4	84	pc	2"x4"	8' 4¾"	470	" " studs

117.22
Figure 2-7.—Bill of materials for frame.

twice the thickness of the sheathing, or 30 ft minus 2(3/4) in., or 29 ft 10-1/2 inches. Therefore, you will need five 12-ft lengths of 2 x 10 for header joists. You would enter this as shown in figure 2-7.

Suppose the drawings show that the vertical distance between the first and second floor finished grades is 9 ft. The length of a first floor stud will equal 9 ft minus (thickness second floor finish floor plus thickness second floor subfloor plus thickness second floor joists plus thickness first floor top and sole plates) plus thickness first floor finish floor, or 9 ft - (5/8" + 3/4" + 7-5/8" + 3(1-5/8")) + 5/8", or 9 ft - 13-7/8" + 5/8", or 7' 10-3/4".

Studs, like joists, will be 16 in. O.C. The number of studs in each 30-ft wall will be 1 plus the value of x in the equation 1:1.33::x:30, or 24 studs. The number in each 20-ft wall will be 1 plus the value of x in the equation 1:1.33::x:20, or 16 studs. The total number of studs, then, will be 2(16), or 80. Suppose that studs will be tripled for posts at corners; this means an additional 4 studs, one for each corner, for a total of 84 studs. You would enter these in the framing bill as shown in figure 2-7.

Again note that there is no allowance for doors, windows, or other wall openings, it being considered that the parts cut out of full-length studs for these openings will supply the need for subsills, headers, and the like. However, any full-length trimmers indicated on the drawings should be added to the total number of studs.

You would continue in the manner indicated to determine the lengths and quantities required for all the remaining frame members. Nail requirements you estimate on the basis of a table like that in table 2-1, in which average quantities and sizes of nails required per each 1000 BF of various types of wood construction are given.

Figure 2-7 shows a total of 970 bd ft in the "joists and sills" category; the quantity of 20d common nails required for this category, then, would equal the value of x in the equation 25:1000::x:970, or about 24 lbs. There are 470 bd ft of ground floor studding; the number of 8d common nails required would equal the value of x in the equation 15:1000::x:470, or about 7 lbs. Obviously, it is best to leave the nail calculations out until after you have entered all the wood construction items in the particular category.

117.168

Table 2-1.—Average Quantities and Sizes of Nails Required Per Each 1000 BF of Various Types of Wood Construction.

Type Construction	Quantity (lbs)	Size and Type of Nail
Joists and Sills	25	20d common
Studding	15	8d common
Rafters	10	8d common
Rafters (additional)	5	16d common
Sheathing	20	8d common
Siding	18	6d common
Exterior finish (as, cornice)	16	8d casing
Interior finish (as, baseboard, casings)	12	8d finish
Flooring, strip, hardwood	30	6d cut
Flooring, softwood	30	8d cut

Brick Quantity Estimate

To estimate quantities of materials and labor required for brickwork, you must first calculate the NET surface area by deducting the total area of all openings. Table 2-2 shows the material and labor requirements for 1,000 sq ft of 1/2" joint brick wall under ordinary conditions. Table 2-3 shows the material and labor requirements for brickwork footings and piers.

Suppose you need to know the number of bricks required for 35 sq ft of 8" basement wall. Table 2-2 indicates that it takes 12,706 bricks to make 1,000 sq ft of wall this type. If it takes 12,706 bricks to make 1,000 sq ft, it takes x brick to make 35 sq ft, and your equation reads:

12,706:1,000::x:35

Consequently, 1,000x = (35 x 12,706), or 444,710, and x = 444,710/1,000. How do you divide anything by 1000? Simply by moving the decimal point three spaces to the left. The number of bricks required for 35 sq ft of wall in this case is, therefore, 444.7.

For face brick showing 8" by 2-1/4" on the face, with 3/8" mortar joints, it takes slightly

117.182

Table 2-2.— Material and Labor Requirements for 1,000 Sq. Ft. of 1/2-Inch Joint Brick Wall.

Character of construction	Thickness of wall (in.)	Number of bricks	Mortar (cu ft)	Approx time laborer (hrs)	Approx time, bricklayer (hrs)			
					Common Bond		Other bonds	
					Lime or cement-lime mortar	Cement mortar	Lime or cement-lime mortar	Cement mortar
Basement walls, solid: Outer 4-in. thickness laid with all joints filled. Other brick laid on full bed of mortar, touching end to end. Vertical space between 4-in. thicknesses filled with mortar Every fifth course headers	8	12, 706	195	97	73	93	------	------
	12	19, 252	314	149	110	140	------	------
	16	25, 797	433	200	129	159	------	------
Walls above grade, solid: Same construction, but vertical space between 4-in. thickness left open	8	12, 706	135	93	84	93	------	------
	12	19, 252	195	140	128	140	------	------
	16	25, 797	255	187	140	172	------	------
Walls above grade, solid: Outer 8-in. thickness laid with as many as possible vertical joints parallel with face of wall left open Other brick in thicker walls laid on full mortar bed but with brick touching end to end and vertical space between 4-in. thickness left open	8	12, 321	195	95	------	------	104	110
	12	18, 867	255	142	------	------	159	168
	16	25, 412	314	189	------	------	179	197
Walls above grade, solid: all joints filled with mortar	4	6, 161	76	46	62	68	------	------
	8	12, 321	195	95	90	99	104	110
	12	18, 482	314	144	135	148	156	164
	16	24, 642	433	192	152	179	179	197

more than 6-1/2 bricks to cover a square foot of wall. Consequently, to determine face brick requirements, you multiply the net area of wall to be faced by 6-1/2, and add a few over, depending on the size of the area. Face brick quantities should be subtracted, of course, from the total brick requirements found as described above.

Ingredient amounts required per cu yd of mortar will depend upon the mix formula of the mortar. Proportions of cement, lime, and sand in mortar range from 1:0.05:2 all the way to 1:2:9. It takes 13 sacks of cement, 26 lbs. of lime, and 0.96 cu yds of sand to make a cu yd of 1:0.05:2 mortar. It takes 3 sacks of cement, 240 lbs. of lime, and 1 cu yd of sand to make a cu yd of 1:2:9 mortar. Tables are available which give the ingredient amounts per cu yd of mortar for all the various proportions within the ranges indicated.

The norm for mortar mixing is about 4 cu yd per man-day. The norm for loading mortar and wheeling it 50 ft is about 8 cu yds per man-day.

Concrete Block Quantity Estimate

It takes about 1.13 standard 8 x 8 x 16 or 12 x 8 x 16 concrete block units to make a square foot of one-block-thick wall area. Consequently, to estimate the number of these units required for a given amount of wall area, you multiply the NET area by 1.13. Because

117.183

Table 2-3.—Material and Labor Requirements for Brickwork Footings and Piers.

Construction	Number of bricks	Mortar (cu ft)	Approx time laborer (hrs)	Approximate time bricklayer (hrs)
Footings: quantities for 100 linear feet				
8-in. wall	2.272	39	18	15
12-in. wall	2,812	48	22	16
16-in. wall	4,592	78	36	24
Piers: quantities for 10-ft height				
8 x 12-in. solid	124	2.25	1.00	1.75
12 x 12-in. solid	185	3.25	1.50	2.50
12 x 16-in. solid	247	4.50	2.00	3.25
10 ¾-in. x 10 ¾-in. hollow brick laid on edge	113	1.00	1.25	2.00

of the difference between the nominal and the actual dimensions of the units, no allowance for thickness of mortar joints needs to be made. Approximately 0.26 cu yds of mortar are required for every 100 blocks. A good mix for concrete block mortar is 1:0.25:4 (cement:lime:sand). By volume one bag of cement, one-fourth bag of lime, and 360 lbs of damp loose sand will make enough mix of this type to mortar about 75 blocks.

For concrete block foundation walls, a 4-man crew pattern is best. Two of the crew are masons who mortar, lift, and lay blocks; the other 2 are helpers who mix and carry mortar, load blocks, wheel blocks from stockpile to job site, then unload blocks. The construction norm for a foundation crew is about 88 blocks per man-day for 8 x 8 x 16 units, or about 76 blocks per man-day for 12 x 8 x 16 units. The norm for the 4-man crew, then, is 4 x 88 or 352 smaller units per day, or, 4 x 76 or 304 larger units. Since the helpers do no placing, the norm for blocks laid per mason per day is one-half of the crew total per day.

The values given assume a distance from stockpile to site of not more than 100 feet. An additional 0.10 man-day per 100 blocks should be allowed for each additional 100 feet. Additional time of 1/2 hour, or a reduction of 12 blocks per mason, should be allowed for every corner or opening encountered.

For small building concrete block walls other than foundation walls, and for concrete block partitions, a 5-man crew pattern is best. The crew consists of 2 masons who lay and point blocks and 3 helpers who mix and carry mortar, carry blocks from stockpile to site, and build and move scaffolds. Construction norms in typical units laid per man-day are as follows:

4 x 8 x 16 . . . . 66 units
8 x 8 x 16 . . . . 62 units
12 x 8 x 16 . . . . 58 units

The average in terms of blocks per mason per day is:

4 x 8 x 16 . . . . 165 units
8 x 8 x 16 . . . . 166 units
12 x 8 x 16 . . . . 145 units

The norm per day for the crew may be found by multiplying the norm per man-day by 5 or the norm per mason per day by 2. The values given make no allowances for pointing. If both sides are to be pointed, the values should be multiplied by 0.90. If only one side is to be pointed, they should be multiplied by 0.95. For each corner column or opening, reduce the productivity average by 1/2 hour or 10 blocks per mason.

Plaster Quantity Estimates

The total volume of plaster required for a job is, of course, the product of the thickness of the plaster times the NET area to be covered. Plaster specifications state a minimum thickness, which the plasterer must not go under, and which he should likewise exceed as little as possible, because a tendency to cracking increases with thickness.

Specified minimum thickness for gypsum plaster on metal lath, wire lath, masonry/concrete walls and masonry ceilings is usually 5/8 in.; on gypsum lath it is 1/2 in.; on monolithic concrete ceilings it is 3/8 inch. For interior lime plaster on metal lath (3-coat work) the specified minimum thickness is usually 7/8 in.; for exterior lime plaster on metal lath it is 1 inch. For lime plaster on interior masonry walls/ceilings, the minimum thickness is 5/8 in.; for lime plaster on exterior masonry, it is 3/4 inch. For lime plaster on interior concrete ceilings, the minimum thickness is 1/16 in. to 1/8 in.; on interior walls, it is 5/8 inch. For lime plaster on exterior concrete, the minimum thickness is 3/4 inch.

For portland cement plaster, either interior or exterior, recommended thickness is 3/8 in. for each base coat (3-coat work) and 1/8 in. for the finish coat.

The YIELD for a given quantity of plaster ingredients, like the yield for a given quantity of concrete ingredients, amounts to the sum of the ABSOLUTE VOLUMES of the ingredients. The absolute volumes of typical plaster ingredients are as follows:

100 lbs. gypsum.	0.69 cu ft
1 cu ft lime putty.	0.26 cu ft
100 lbs. hydrated lime	0.64 cu ft
100 lbs. sand	0.61 cu ft
94 lbs. portland cement	0.49 cu ft

The above list indicates, for example, that 94 lbs of portland cement, which has a loose volume of 1 cu ft, has an absolute volume (that is, a solid or exclusive-of-air-voids volume) of only 0.49 cu ft. Therefore, 94 lbs of portland cement contributes a volume of only 0.49 cu ft to a portland cement plaster (or concrete) mix.

The absolute volume of the last ingredient, WATER, is the same as its "loose" volume, which is 0.13 cu ft per gallon.

Suppose now that you want to determine the yield of a plaster mix containing 100 lbs neat gypsum plaster (1 sack) to 2.5 cu ft of damp loose sand. Two and five-tenths cu ft of sand weighs about 275 lbs (2.5 x 110). Sand has an absolute volume of 0.61 cu ft per 100 lbs; therefore, the absolute volume of the sand in the mix is 275/100 x .61, or 1.68. This figure should be used in all future calculations based on this mix. This naturally will change the yield from 3.25 to 3.41.

The water will contribute 0.13 cu ft of volume to the mix for every gallon of water added. For approximate yield calculations, you can assume that 8 gals of water will be used for every 100 lbs of cementitious material. There are 100 lbs of gypsum plaster in question here, which means 8 gals of water. The water volume, then, will be 8 x 0.13, or 1.04 cu ft.

The yield for a 1-sack batch of this mix will be the sum of the absolute volume, or 0.69 cu ft (for the gypsum) plus 1.52 cu ft (for the sand) plus 1.04 cu ft (for the water), or 3.25 cu ft.

Suppose that the plastering job is a wall with a NET area of 160 sq ft, with a specified total plaster thickness of 5/8 in., and a finish coat thickness of 1/16 inch. You are doing two-coat work (only a single base coat), and you want to estimate ingredient quantities for the base coat. The thickness of the base coat will be 5/8 in. minus 1/16 in., or 1/16 in., which equals about 0.046 ft. The volume of plaster required for the base coat, then, will be 160 x 0.046 or about 7.36 cu ft.

The yield for a 1-sack batch is 3.25 cu ft; therefore, the job calls for a batch with sacks to the number indicated by the value of x in the equation 1:3.25::x:7.36, or about 2.3 sacks. The number of parts of sand required equals the value of x in the equation 1:2.5::2.3x or 5.75 parts. There are 100 lbs of sand in a "part," and 100 lbs of gypsum in a sack. Therefore, for the base coat, you will need 230 lbs of gypsum and 575 lbs of sand.

EQUIPMENT ESTIMATES

An equipment estimate, for purposes of this discussion, is a listing of the type of equipment, the amount of time and the number of pieces required to construct a given project. Information from work element estimates, drawings and specifications, and information obtained from inspection of the site provide the basis for preparing the equipment estimate. Figure 2-8 illustrates the type of information shown in an equipment estimate. It is not practical to use a form with columns for work quantities, equipment quantities, and operation days when pre-preparing the equipment estimate. However, forms with certain information in the heading, such as that shown in the heading of the form in figure 2-8, will save estimator time.

Equipment estimates are used together with work schedules as a basis for determining the construction equipment requirements of a project and the total construction equipment requirements of a Seabee deployment. This estimate includes such items as mortar mixers, wheel barrows and chain saws, as well as automotive equipment. Equipment estimates may also be used as a basis for estimating the amount of spare parts, the number of mechanics, the size of shops, and the tools and shop equipment needed to maintain construction equipment in operating condition during a deployment.

When preparing the equipment estimate, the work element estimate should be examined and all work elements requiring equipment for their performance should be listed. For each work element on this list, the type of equipment and method of performing the work should be selected. The production rate per day should be estimated for each piece of equipment. The quantity

SHEET 3 OF 3

ESTIMATED BY Mc Crea DATE 8-24-6-

CHECKED BY Murphy DATE 8-30-6-

EQUIPMENT ESTIMATE

MCB 12 LOCATION Guam YEAR 196-

PROJECT 01 DESCRIPTION Site Preparation

Equipment Required for Loading and Hauling

3 - 2 1/2 cy Endloaders.

1 - Bulldozer to keep pit in shape.

1 - Grader to keep haul road in shape.

15-10 Ton trucks hauling (1 or 2 extra trucks should be added to assure that a truck will always be waiting to be loaded so that endloader will work at full capacity).

2400 cy will be hauled each day.

$\frac{2400}{1200}$ = 2-tractors & tandem sheepsfoot rollers for compaction.

$\frac{2400}{1200}$ = 2- Bulldozers to spread earth.

1 - Water truck with sprinkler.

1 - Wobbly wheel roller (standby for sealing top of fill before rains).

Note: this is a more efficient operation as production has been tripled but equipment has not, and total equipment is working about or close to capacity as can be expected.

145.5

Figure 2-8. — Equipment estimate.

of work is divided by the production rate per day to find out how many days of operation are required to perform the work. You will be briefed later in this discussion on various factors affecting production and on sources of information used in determining equipment production rates. Some elements of work require several items of equipment to be used as a group rather than individually; in these cases, the days of operation should be shown as days of group operation.

After determination of the number of days of equipment operation required, the work schedule should be consulted to find the time allotted for completion of the work element. It may be necessary to work several pieces or groups of equipment at the same time in order to complete the work within the scheduled time. Also, it may be advantageous to use several pieces or groups of equipment at the same time because it would result in more efficient operation. An equipment schedule should be prepared

for the total deployment using the work schedule to determine when the work will be performed. The number of pieces of each equipment type required at any one time can be determined from this schedule. This schedule will indicate the peak workloads for each equipment type. A study of the peak loads may show that it is desirable to revise the work schedule to more evenly distribute the equipment workload and thereby reduce the amount of equipment required for a deployment.

Following a review of the equipment and work schedules, and making all possible adjustments to them, a list of the equipment requirements for the deployment can be prepared. In preparing this list, downtime should be anticipated and sufficient equipment added so that when equipment is out of service awaiting repairs a reserve piece is available for use. This is especially important for automotive equipment. The number of pieces of equipment required for a deployment is obtained by adding the required reserve equipment of each type to the peak figure indicated by the equipment schedule.

Factors Affecting Production

When you realize the importance of equipment in getting construction work done, you can see that special care is needed in preparing equipment estimates. You will often have to consider a number of factors before arriving at an estimate of how much work to expect from an individual piece of equipment. Some of the important factors affecting equipment production are: average speed at which the equipment will be operated, type of materials to be handled, experience of operators, age and condition of the equipment, time allotted for completion, climate, and safety.

EQUIPMENT SPEED.—Maximum speeds are established either by a governing authority such as a highway or street speed limit, or by a command such as an operating limit on the equipment. In either case the speed limits must be considered when estimating the average hauling speed which, in turn, determines the amount of material the equipment will move in one day. The estimator should not make the mistake of using the speed limit as the average speed at which equipment will be operated. Equipment speed will usually average 40 percent to 65 percent of speed limits depending upon condition of the road, number of intersections to be crossed, amount of traffic and length of haul. Longer hauls will usually result in higher average speeds, other conditions being equal.

TYPE OF MATERIAL TO BE HANDLED.—The type of material to be handled has a definite effect on the amount of time required. For example, wet sticky clay is slower to dig, load, and dump because it sticks to the bucket, pan, or truck bed, and requires jarring and shaking to loosen and dump the load. On the other hand, damp sandy loam does not stick to buckets, beds or pans and requires little or no jarring or shaking; therefore, the time required for these extra maneuvers is saved. Sand handles easier and quicker with a clamshell bucket than does gravel or crushed rock. When lifting with a crane, bulky, hard-to-rig material and equipment require more time to load and unload. For example, a large timber or steel beam is easy to handle by simply putting a choker sling around the midpoint and lifting while a large bulky piece of equipment would require bridle slings placed so as to balance the equipment as it is lifted. Several trial lifts usually are required, moving the slings after each lift, before the equipment is balanced for safe lifting.

EXPERIENCE OF OPERATIONS.—The experience of the operator must be given consideration when estimating production of equipment. An experienced man operating equipment knows the short cuts and performs work with minimum effort and movement, thus getting maximum production from a machine. For example, an experienced operator will spread a load of dirt with less passes than an inexperienced man and do a better job of spreading. Also, inexperienced operators are likely to forget some of the required maintenance operations and as a result, tend to have more downtime with their equipment.

AGE AND CONDITION OF EQUIPMENT.—The age and condition of equipment certainly must be considered in estimating the number of days required to perform work. Old equipment and poorly maintained equipment are more likely to have downtime than new equipment or equipment in good operating condition. Also, old and worn equipment responds more slowly to the operator, has less power and is generally less efficient. Downtime of equipment sometimes affects more than just its own operation. For example, if one of five trucks hauling dirt broke down it would affect only its own operation, but if the equipment loading those five trucks broke

down it would stop all of the trucks plus the equipment spreading and compacting the dirt being hauled.

TIME ALLOTTED FOR COMPLETION. — The time allotted for completion affects production if crews must work long hours daily, or if work must be performed under crowded conditions in order to complete the project within the allotted time. Men working long hours daily without sufficient rest and relaxation tend to slow down, especially if this continues for several weeks, and production per machine and per man is lowered. Also, when work is performed under crowded conditions, efficiency drops, and production is lowered. More efficient operation and better production are usually obtained by working two or more shifts per day.

CLIMATE. — Climate, of course, has a considerable effect on production of equipment in outside work. Rain slows down the work, and frequently stops it for the remainder of the day and sometimes for several days. In climates with considerable rainfall, as in Okinawa, equipment will not produce as much per hour or per week as in dry climates. Extremely cold weather slows down the operator and lowers the efficiency of the equipment, thus lowering production. Climate also has an effect upon the spare parts required to maintain equipment in operating condition and should be considered when determining spare part requirements. Very dry climates with considerable dust cause more rapid wear on parts such as engines and bearings, while wet climates with equipment operating in mud cause more rapid wear on parts such as track assemblies.

SAFETY. — Safety factors sometimes limit the amount of work which can be produced with a machine, and therefore they must be considered as a production factor. For example, although the manufacturer's crane rating may show it to be capable of lifting 40 tons with a 70-foot boom at a 45° angle, for reasons of safety the maximum lifting capacity of that particular crane may have been limited to 85 percent of the manufacturer's rating. The crane can then only be used to lift 34 tons with a 70-foot boom at a 45° angle. Certain pieces of equipment may have their speed limited because of safety reasons, which would reduce the rate of production as discussed earlier in the section on "Equipment Speed."

Equipment Production Rates

Numerous sources of information about equipment production rates are available. These sources include manufacturer's tables and diagrams, Government manuals, and estimating books. Production rates are usually available in most Seabee operations offices. However, it is not practical to draw up a production table which would consider the particular combination of factors affecting production on a given project. Production rates found in tables, therefore, must be adjusted to fit the conditions expected on the particular project being estimated. In order to make the adjustment intelligently, the estimator should know on what basis the rate in the table was established. This information is usually contained in the foreword, in notes for the table, or in instructions for using the table.

MANPOWER ESTIMATES

A manpower estimate is a listing of the number of man-days required to complete the various work elements of a specific project. These estimates may show only the man-days for each work element and the total man-days, or they may be in sufficient detail to show the number of man-days of each rating—such as Builder, Steelworker, Utilitiesman, and so on—for each work element. Manpower estimates are used in determining the number of men and ratings required on a deployment, and provide the basis for scheduling manpower in relation to construction progress. Two types of manpower estimates that you may prepare are preliminary and detailed estimates.

PRELIMINARY manpower estimates are estimates prepared from limited information, such as general descriptions of projects, or preliminary plans and specifications containing little or no detailed information. They are usually prepared on the basis of area, length, or other suitable general dimensions, to establish rough cost estimates for budget purposes and/or to program manpower broadly for succeeding years.

DETAILED manpower estimates are more accurate estimates, used to determine manpower requirements for specific projects.

Manpower Estimating Tables

For both preliminary and detailed manpower estimates, you will probably have available manpower production rate tables relating to all the

ROAD, WALK, PARKING AREA AND FENCE INSTALLATION

WORK ELEMENT DESCRIPTION	UNIT	MAN-DAYS PER UNIT		
		ADVERSE CONDITION	AVERAGE CONDITION	FAVORABLE CONDITION
For preliminary estimates only:				
Roads (including grading and base)				
Asphalt	1000 SY	130	65	27
Concrete	1000 SY	240	140	67
Gravel	1000 SY	75	45	20
Concrete curbs	1000 LF	260	160	75
Parking areas (includes grading, base, and curbs)				
Asphalt	1000 SY	140	70	30
Concrete	1000 SY	240	150	72
Gravel	1000 SY	85	50	22
Walks				
Asphalt	1000 SF	34	23	12
Concrete	1000 SF	44	30	15
Pipe culverts (includes concrete headwalls) (No excavation or backfill)				
24" and smaller	LF	0.56	0.34	0.18
26" to 45"	LF	0.95	0.58	0.30
48" to 72"	LF	1.50	0.93	0.48
Chain link fence				
5' high	1000 LF	111	74	37
8' high	1000 LF	153	102	51

82.86

Figure 2-9.—Preliminary manpower estimating table.

common types of construction work. Figure 2-9 shows a preliminary manpower estimating table from the Seabee Planner's and Estimator's Handbook. In preparing preliminary estimates on the basis of area or linear measurement, it is first necessary to compute the area or other measurement of the project from information at hand. Next the conditions under which it will be constructed must be considered, and a suitable man-day per unit figure selected. The quantity of measurement is then multiplied by the man-day figure to obtain the estimated man-days required for the project.

Suppose, for example, that the project is the construction of 5000 lin ft of concrete highway 30 ft wide. The area here is 5000 x 30, or 150,000 sq ft, which is 150,000/9, or 16,700 sq yd. Suppose it is assumed that construction will proceed under average conditions. Under such conditions, the table shown in figure 2-9 indicates that 140 man-days are required for every 1000 sq yd of concrete highway. Man-

day requirements for 16,700 sq yd, then, would equal the value of x in the equation 140:1000:: x:16,700, or 2338 man-days.

Obviously the overall work element "construct 16,700 sq yd of concrete highway" contains a number of subelements, such as (for a new highway over rough country) clearing and grubbing, excavating and earth-moving, preparing base and subbase, setting forms, batching and mixing concrete, casting concrete, finishing concrete, curing concrete, stripping forms, and so on. A detailed manpower estimate would determine the man-day requirements for each of these work elements. The estimator refers to a detailed manpower estimating table like the one shown in figure 2-10.

Figure 2-11 shows a WORK ELEMENT SUMMARY SHEET on which the manpower require-

SITE PREPARATION – CLEARING AND GRUBBING

WORK ELEMENT DESCRIPTION	UNIT	MAN-DAYS PER UNIT		
		ADVERSE CONDITION	AVERAGE CONDITION	FAVORABLE CONDITION
Clearing and grubbing by hand:				
Cutting trees and brush	1000 SY	7.0	4.8	2.0
Piling and burning	1000 SY	1.7	1.2	0.5
Digging and blasting stumps	each	0.3	0.2	0.1
Cutting large trees	each	0.6	0.4	0.2
Clearing and grubbing with equipment:				
Clearing trees and brush	1000 SY	0.7	0.4	0.2
Rooting out stumps	each	0.2	0.1	0.05
Loading and hauling	1000 SY	2.8	1.6	0.8
Burning trees and brush	1000 SY	0.7	0.4	0.2
For quick estimates;[1]				
Clearing and grubbing:				
By hand	1000 SY	9.6	6.6	2.8
With equipment	1000 SY	2.2	1.3	0.65

Typical crew: Hand work – 1 crew leader, 4 to 8 men with brushhooks and axes, 1 to 2 men with portable chain saws.

Typical crew: With equipment – 1 crew leader, 1 bulldozer operator, 2 to 5 men with chain saw and axes cutting and trimming large trees.

Typical crew: Burning – 2 to 5 men.

Note: Most stumps can be rooted out with a bulldozer unless the ground is very hard. Brush should not be burned until it has dried for several weeks. Old tires burned with the brush pile help to keep the fire going.

[1] Based on burning brush and trees at site, and 1 large tree per 1000 SY.

82.87

Figure 2-10. — Detailed manpower estimating table.

SHEET 1 OF 6

ESTIMATED BY Smith DATE 7-7-6

CHECKED BY Jones DATE 8-10-6

WORK ELEMENT ESTIMATE
SUMMARY SHEET

MCB 15 LOCATION Saipan YEAR 196

PROJECT 08 DESCRIPTION Staging-Out Warehouse

WORK ELEMENT	QUANTITY	MAN-DAYS PER UNIT	MAN-DAYS REQUIRED
Footings and foundations			
Machine excavation	1860 CY	40/1000 CY	74.4
Machine backfill	1277 CY	6/1000 CY	7.7
Hand compaction	1277 CY	0.30/CY	383.1
Spread excess-earth machine	583 CY	1.6/1000 CY	0.9
Form and strip	11,083 SFCS	44/1000 SFCS	487.7
Place reinforcing steel	34.6 ton	10/ton	346.0
Place, finish, & cure concrete	582.8 CY	0.75/CY	437.1
Total man-days			1736.9

82.88

Figure 2-11.—Work element summary sheet with manpower requirements computed.

ments for each of the elements shown have been computed. For the man-days per unit production factors the estimator referred to the tables shown in Table 2-4 and Table 2-5. For machine excavation, footings and foundations, Table 2-4 shows, for 1000 cu yd, under favorable conditions 12 man-days, under average 25, under adverse 50. The estimator selected 40, a figure only a little better than adverse. He may have known that the ground was exceptionally hard, or that the available equipment was old and worn, or that there were some other adverse circumstances relating to the excavating.

For the machine backfill, Table 2-4 shows 6 man-days per 1000 cu yd under average conditions; you can see that the estimator selected this figure. For hand compaction he selected 0.30 man-days per cu yd, a figure just a little better than that given for average conditions in Table 2-4. For machine spreading of excess

82.89

Table 2-4. — Excavation for Footings and Foundations.

EXCAVATION FOR FOOTINGS AND FOUNDATIONS

WORK ELEMENT DESCRIPTION	UNIT	MAN-DAYS PER UNIT		
		ADVERSE CONDITION	AVERAGE CONDITION	FAVORABLE CONDITION
Machine evcavation for footings and foundations:				
Excavation [1]	1000 CY	50	25	12
Load excess earth	1000 CY	9.0	4.5	2.0
Haul excess earth	1000 yd miles	5.2	3.1	1.4
Spread spoil pile	1000 CY	2.1	1.4	0.7
Spread excess earth	1000 CY	4.5	3.0	1.5
Backfill	1000 CY	9	6	3
Compaction	1000 CY	12	8	4
Hand excavation for footings and foundations:				
Excavation	CY	1.2	0.7	0.3
Load excess earth	CY	0.8	0.4	0.2
Spread excess earth	CY	0.18	0.12	0.06
Backfill	CY	0.35	0.20	0.10
Compaction	CY	0.55	0.35	0.15
For quick estimates for excavating footings and foundations: [2]				
Machine excavation, complete	1000 CY	72	38	18
Hand excavation, complete	CY	2.1	1.0	0.5

Typical crew: Machine work – 1 crew leader, 2 men on excavating equipment, 2 to 6 trucks with operators, 1 man on equipment spreading and backfilling, 1 man on compacting equipment.

Typical crew: Hand work – 1 crew leader, 2 to 10 men excavating, loading and/or spreading excess dirt, backfilling and tamping.

[1] Includes trimming and fine grading.

[2] Includes removal and disposal of excess dirt, backfilling, and compaction.

earth he selected 1.6 man-days per 1000 cu yd. a figure not quite as good as that given for favorable conditions in Table 2-4.

For forming and stripping the estimator selected 44 man-days per 1000 sfcs, the figure given for average conditions in Table 2-5. For placing reinforcing steel he again used the average-conditions figure: 10 man-days per ton. For placing, finishing, and curing the concrete he selected 0.75 man-days per cu yd, about the figure given for adverse conditions in Table 2-5. He may have known that the mixing and finishing equipment was in poor condition, or that the skill of the masons was below average.

Factors Affecting Manpower Production

Principal factors affecting manpower production are: weather conditions during the construction period, skill and experience of the crew, time allotted for completion of the job, size of the crew to be used, accessibility of the site, and types of material and equipment to be used. The influence of weather conditions, skill and experience of the crew, and accessibility of the site need not be explained.

The time allotted may be so short as to require a "rush" job, with crews working long hours and perhaps 7 days a week. A man's production per hour decreases sharply under these conditions. With regard to the size of the crew, if a work area is crowded men are likely to get into each other's way, to talk and visit instead of working, or to cause production to fall off in other ways. This, of course, causes the man-hours required for a job to rise.

Many examples of how type of material affects man-day requirements could be cited. For instance: some types of soil are easier to dig and spread than others; some types of rock are easier to quarry and crush than others; some form materials require less labor than others; and some types of sheet piling are easier to drive than others.

The effect of type of equipment, too, is easy to make out. If earth is to be hauled in 5-yard trucks, a certain number of drivers will be required. If it is to be hauled in 10-yard trucks, only half as many driver man-hours will be required for the same amount of haul output.

82.90

Table 2-5. — Concrete Footings and Foundations.

CONCRETE FOOTINGS AND FOUNDATIONS

WORK ELEMENT DESCRIPTION	UNIT	MAN-DAYS PER UNIT		
		ADVERSE CONDITION	AVERAGE CONDITION	FAVORABLE CONDITION
Erect and strip forms	1000 SFCS*	70	44	22
Place reinforcing	Ton	16	10	5
Place, finish, and cure concrete	CY	0.7	0.4	0.2
For quick estimate: Concrete footing and foundation, complete	CY	3.4	2.0	0.8

Typical crew: 1 crew leader, 3 men erecting and stripping forms, 3 men placing reinforcing steel, and 4 men placing, spading, vibrating and finishing concrete.

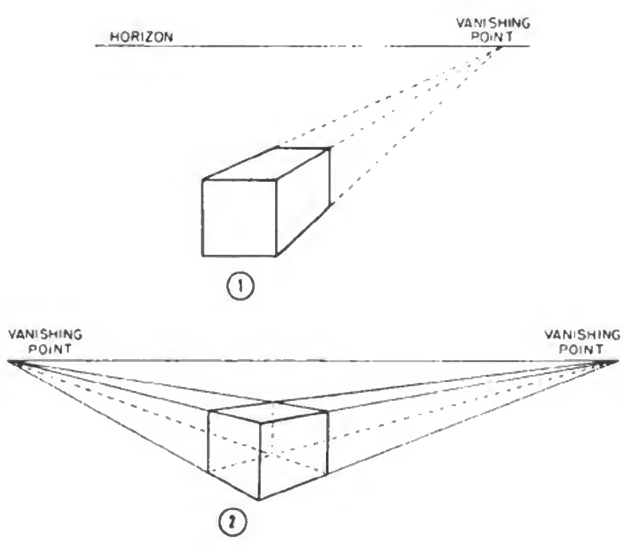
* Square feet of contact surface.

Similarly, more man-hours will be required for concrete placement by wheelbarrow than would be required for placement by bucket-and-crane.

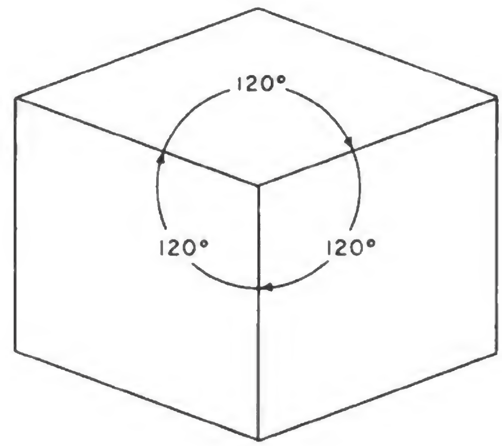
TECHNICAL DRAWINGS

As a Builder supervisor, it is important that you have a thorough knowledge of technical drawings. You will find this knowledge useful in estimating materials and labor, in scheduling, and in job planning. Since much of the work that is done by Builders is indicated on technical drawings, you should clearly understand the drawings yourself, and be able to assist your subordinates in reading and working from them. In certain situations—such as the absence of drawings or to explain a part of a drawing—you may also have to prepare sketches for your men to follow.

A technical drawing is, simply, any drawing whose principal purpose is to show technical information as against a drawing whose principal purpose is decorative or illustrative. A technical drawing could show an object as it actually appears to the human eye; this type of 3-dimensional drawing is called DIMINISHING PERSPECTIVE. In figure 2-12 (1) an oblong box is shown in diminishing perspective. Actually, the front and rear upper edges of this box are of equal length. In the perspective drawing the line which reoresents the front edge, is longer than the line which represents the rear edge. Also, receding lines which are parallel to each other on the object itself appear to be converging toward each other in the perspective drawing. In figure 2-12 (1) receding lines are converging toward a single VANISHING POINT; this type of drawing is called ONE-POINT perspective. In figure 2-12 (2) receding lines are converging toward two vanishing points; this is known as TWO-POINT perspective.



65.20
Figure 2-12. — Perspective drawings.



45.231
Figure 2-13. — Isometric projection.

SINGLE-PLANE PROJECTION

In a technical drawing, points and lines on the object are presumed to be PROJECTED onto a flat plane called the PLANE OF PROJECTION. A drawing of the types shown in figure 2-12 is called a SINGLE-PLANE projection, because it presents a 3-dimensional view of the object on a single plane.

Single-plane projections have been devised in which the diminishing-with-distance distortion of the prespective drawing is to a large extent eliminated.

Isometric Projection

The most commonly used of these projections is the ISOMETRIC projection. Figure 2-13 shows an isometric projection of a cubical block. The block is presumed to be so placed and tilted as to cause each of its surfaces to form an angle with the plane of projection. With the block so placed, each of the edge-lines, as it projects onto the plane, is shorter

than the original line on the object by exactly the same proportion. In a technically correct isometric projection this foreshortening is calculated and deducted from the object dimensions by the draftsman making the projection. However, since the scale of reduction is the same for all lines, the foreshortening may be ignored, and the dimensions made equal to those on the object (with reduction, of course, to the scale of the drawing for a less-than-full-scale drawing). This type of isometric representation, in which the foreshortening of lines is ignored, is called an isometric DRAWING rather than an isometric projection.

In an isometric drawing, all ISOMETRIC lines appear in their true dimensions (as reduced or enlarged, of course, in a drawing not made to full scale). An isometric line is a line on the object which forms the isometric angle with the plane of projection. All of the lines visible in figure 2-13 are isometric lines; therefore, in an isometric drawing they would all appear in their true dimensions. However, a diagonal line (for example) drawn on the upper face of the block between two opposite corners would be a NONISOMETRIC line, and this one would NOT appear in its true dimensions on the drawing.

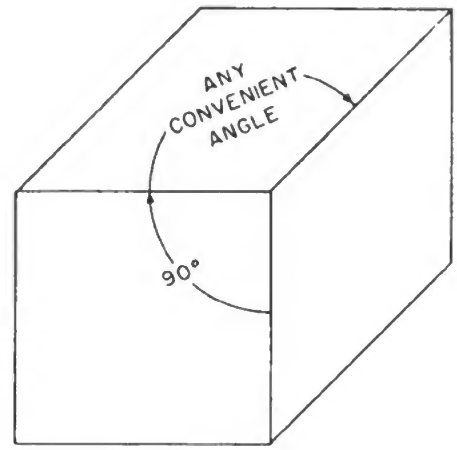
An isometric projection or drawing is constructed on the ISOMETRIC AXIS indicated by the 120-degree angles shown in figure 2-13. Any isometric line in the drawing is, as you can see, parallel to one or another of the three legs of the axis. For a nonisometric line you locate the end-points of the line by measurement along isometric lines, and then connect the end-points.

Cavalier Projection

In isometric projection the LINES OF PROJECTION (that is, the imaginary lines which project points and lines from the object to the plane of projection) are presumed to be perpendicular (at right angles to) the plane of projection. In CAVALIER projection the lines of projection are presumed to make a 45-degree angle with the plane of projection.

In figure 2-13 (isometric projection) there is, as you can see, no face of the block that is parallel to the plane of projection. Instead, all faces make the isometric angle with the plane of projection.

Figure 2-14 shows the same block in cavalier projection. Here the front face of the block is presumed to be parallel to the plane of projection. Because the projectors are presumed to



45.228
Figure 2-14. — Cavalier projection.

form a 45-degree angle with the plane of projection, the top and one side of the block are visible as well as the face. Again, all the visible lines appear in their true dimensions. Any NORMAL line on a cavalier projection, like any isometric line on an isometric drawing, will appear in its true dimensions. A normal line is one which is parallel to one or another of the legs in the cavalier axis. As shown in figure 2-14, the cavalier axis has two legs at right angles to each other and a third at any convenient angle to one of the other two. The third leg is known as the RECEDING axis.

All of the lines shown in figure 2-14 are normal lines; therefore, since the figure represented is a cube, they are all of the same length, appearing as they do in their true dimensions. Again, a diagonal line drawn between corners on the top face would be a NONNORMAL line (not parallel to any leg of the axis), and would not appear in its true dimensions.

Cabinet Projection

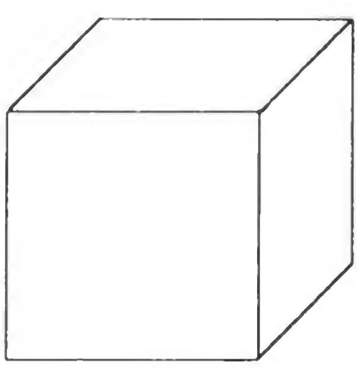
You can see that the block in figure 2-14 doesn't resemble a cube; the depth dimension looks longer than the height and width dimensions. This is because of the fact that the cavalier projection corrects the eye's diminishing optical illusion, and the eye is used to this illusion. To make a cavalier projection look more "natural," the receding axis is sometimes drawn to one-half of the scale of the other two axes. A projection of this kind is

called a CABINET projection. The block shown in figures 2-13 and 2-14 is shown in cabinet projection in figure 2-15. You can see that the eye is better satisfied that this figure is a cube, but this appearance of "naturalness" is obtained by introducing a considerable error into the drawing (dimensions along the receding axis are one-half of the true dimensions).

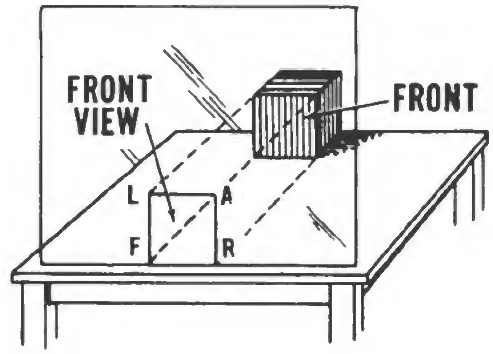
ORTHOGRAPHIC MULTIVIEW PROJECTION

A projection in which the projectors are presumed to form a right angle with the plane of projection is an ORTHOGRAPHIC projection. One in which the projectors form an OBLIQUE (other than right) angle with the plane of projection is an OBLIQUE projection. Therefore, an isometric projection is an orthographic projection, but cavalier and cabinet projections are oblique projections.

Now, on an isometric or cavalier projection all isometric or normal lines appear in their true dimensions, and lines which are parallel to each other on the object are likewise parallel to each other on the projection. Therefore, these projections are free of much of the distortion which appears in a perspective drawing. Nevertheless, both the isometric and the cavalier projection contain significant distortions. If you examine the figures which show these projections, you will see that all of the angles in an isometric projection and many of those in a cavalier projection are distorted. In an isometric projection all corner lines which join at a right angle on the cube itself join at oblique angles on the projection. The same is true of the cavalier projection, with the exception of



45.229
Figure 2-15. — Cabinet projection.



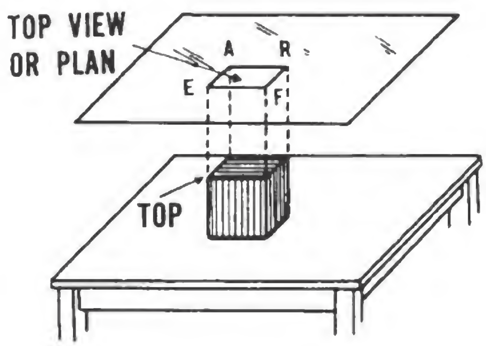
117.1
Figure 2-16. — Front elevation in an orthographic projection.

corner angles relating to the front face of the cube.

On the cavalier projection the front face of the cube is represented with complete accuracy in that not only the front face dimensions, but likewise the front face corner angles, are true. The reason is the fact that in the cavalier projection the front face of the cube is presumed to be parallel to the plane of projection. It follows, then, that to show all surfaces of the cube with complete accuracy would require a separate plane of projection for each surface of the cube-meaning that a MULTIPLANE, rather than a single-plane, projection would have to be used.

A cavalier projection is an oblique projection. But to show all surfaces of the cube accurately by multiplane projection, orthographic projection (in which the projectors are presumed to form a right angle with the plane of projection) is more convenient and more accurate than oblique projection. Therefore, orthographic multiplane (more commonly called MULTIVIEW) projection is the most widely used method of presenting technical information in graphic form.

The principle of orthographic multiview projection is illustrated in figures 2-16, 2-17, and 2-18. Bottom, back, and left side views would be similarly projected. Figure 2-19 illustrates the method commonly used in the arrangement of the views. In the upper part of this figure there is an isometric drawing of an oblong block. Below, there is a multiview orthographic projection which shows all six faces of the block, there being a separate view for each face.

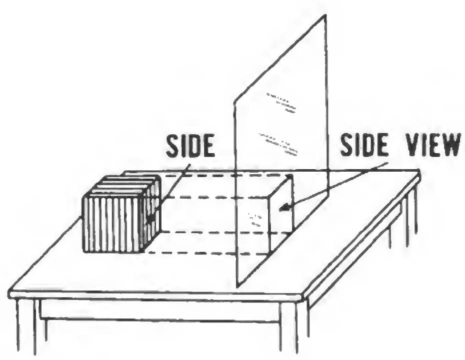


117.2
Figure 2-17.—Plan view in an orthographic projection.

Note that in the multiview orthographic projection both the dimensions and the angles are true, while in the isometric projection the dimensions are true but the angles are not. Multiview orthographic projection, then, is the method of technical drawing by which an object can be depicted with the most complete accuracy. Isometric projection, on the other hand, gives you a better idea of the general appearance of the whole object in a single view.

TECHNICAL SKETCHING

A technical drawing is made for the purpose of conveying technical information. It follows from this that a technical drawing contains only the graphic presentation required to show the required technical information completely. Consider figure 2-14, for example. In this figure



117.3
Figure 2-18.—Side elevation in an orthographic projection.

the orthographic multiview projection shows six views of the block. It so happens, however, that all significant information about the block could be shown in three views (say, front, top, and right side), or even in only two (say, front and top). Therefore more than three, or more than two, views would be superfluous.

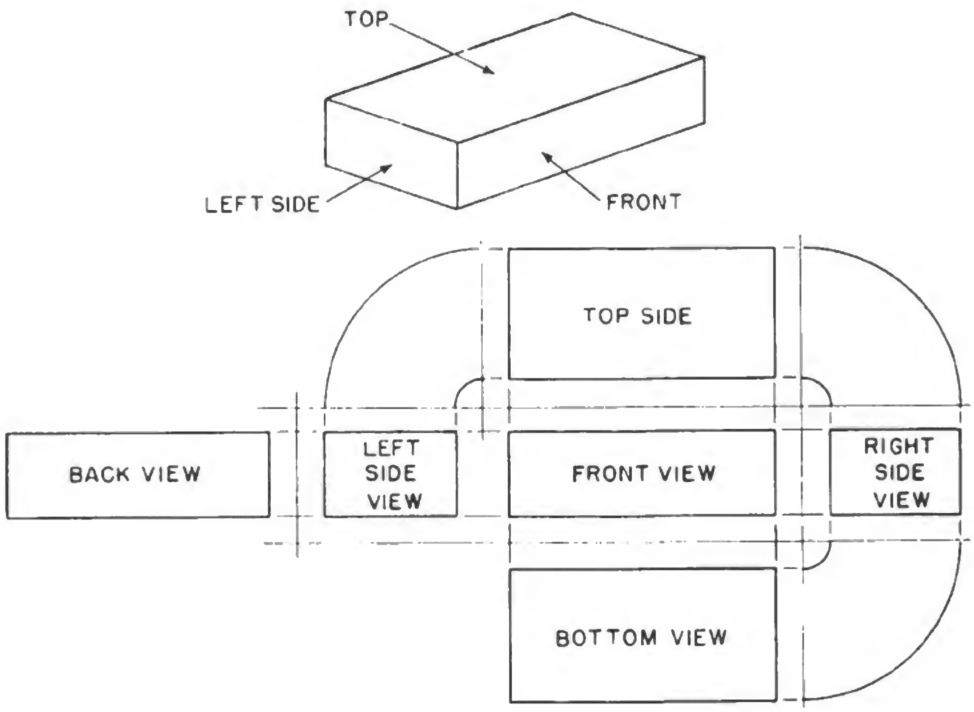
In one sense of the term, a MECHANICAL drawing means a floor plan which shows the utility system on a particular floor of a structure. In another sense of the term, however, mechanical drawing means NONFREEHAND drawing—that is, drawing in which all straight lines are made with the help of a straightedge, circles with the help of a compass, noncircular curves with the help of a french, ship, or railroad curve, and so on. The opposite of this type of mechanical drawing is FREEHAND drawing, in which lines, circles, and curves are drawn freehand.

Freehand technical drawing is called TECHNICAL SKETCHING. Basically, it is only the freehand character of a technical sketch that distinguishes the sketch from the more formal type of technical mechanical drawing made by a draftsman. The sketch, like the formal drawing, must show accurately all the technical information required for actual construction of the structure. Formal technical drawings are, in fact, often made by draftsmen from technical sketches prepared by design engineers.

The first consideration in planning a technical sketch is: What is the essential technical information which the sketch must convey? Obviously, for a structure, all significant dimensions are of prime importance. Significant dimensions include not only the lengths, heights, and thicknesses of walls, but also all dimensions required to locate such features as doors, windows, floors, and partitions.

The next consideration in planning a technical sketch is: What will the structural arrangements be—that is, what structural members will be required, what will their dimensions be, and how will they be arranged?

Suppose, for example, that you want to make a technical sketch of the formwork for an 8-in. thick concrete foundation wall 30 ft long by 5 ft high. What size studs will you use, and how far apart? What size wales, if any, and how far apart? What size bracing, and how many braces? Methods of determining these values are described in chapter 5.



117.4
Figure 2-19.—Isometric and multiview orthographic projections of the same object.

How far down must you scale your sketch to make it fit your paper conveniently? Suppose your sketch paper is the common size of 8 in. by 10-1/2 in. The longest dimension for your formwork is 30 ft. Suppose you let 1/2 in. equal a foot. Then 30 ft will measure 15 in. to scale, which is too long for your paper. However, if you let 1/4 in. equal a foot, 30 ft will measure only 7-1/2 in. to scale, which is convenient enough for your paper. But in this case the 5 ft of height will scale down to only 1-1/4 in. on the paper—rather small for showing structural details.

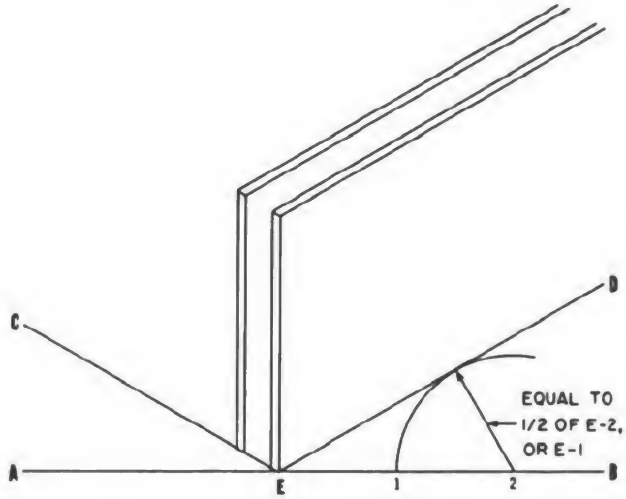
But do you really need to show formwork 'or the whole wall in your sketch? Isn't it necessary to represent only enough of the formwork to show all significant structural details—a sketch containing, say, 5 or 6 studs? Suppose you have determined that studs must be spaced 16 in. O.C. To show a sketch containing 6 studs, you need show only a little over 6 ft 8 in. of wall. If you let 1/2 in. equal 1 ft, your wall length will scale down to about 3-1/3 in. and the height to 2-1/2 in. If you let 3/4 in. equal 1 ft, your scale length and height will be 5 in. and 3-3/4 inch. Either of these scales will fit your paper.

It's a good idea at this point to take a piece of scratch paper and write down all the significant dimensions for your sketch. In this case these dimensions are:

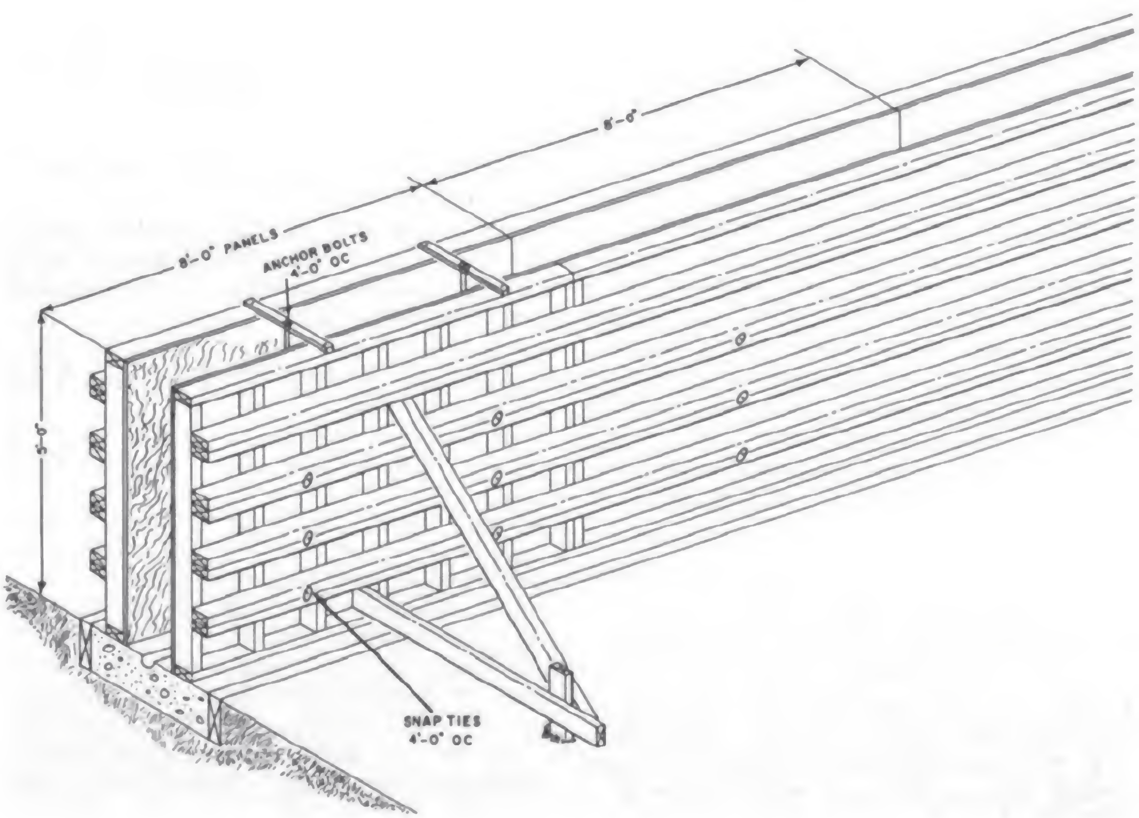
Length of wall to be shown	6 ft 8 in.
Height of wall	5 ft
Thickness of wall	8 in.
2 x 4 stud spacing	16 in. O.C.

You will use, then, either the 1/2 or 3/4 in. to the foot scale on your architect's scale to scale these dimensions on the sketch.

For sketching this section of formwork, an isometric drawing would seem to be the best idea. Start by sketching the isometric axis as shown in figure 2-20. Draw the horizontal line AB, and from E draw EC and ED at 30° to AB. If you do not have a protractor, you may get a 30-degree angle by laying off two equal units along EB, and striking an arc with a radius of one of the equal units laid off along EB. Then draw ED tangent to the arc as shown in figure 2-20.



117.5
Figure 2-20. — Constructing isometric axis.



117.6
Figure 2-21. — Technical sketch of wall formwork.

Proceed now to line in the rest of the sketch, as shown in figure 2-21. For the techniques of sketching, see the chapter entitled "Technical Sketching" in Blueprint Reading and Sketching, NavPers 10077-C. Although sketching is, by definition, freehand drawing, it is of course not essential that you draw all your lines freehand. If circumstances permit the use of a straightedge, you will find the drawing of straight lines much easier.

Note that in figure 2-21, only essential information needed for actual construction is included. Only a single pair of stud braces is shown, for example, although additional braces are stipulated. Since additional sketches of braces would convey no information not available in a single sketch, the additional sketches are left out. On this basis it would not, in fact, have been necessary to show more than a single pair of studs and a single wale.

CHAPTER 3

SCHEDULING

In construction work, schedules play an important part in keeping production flowing evenly and getting a project done on time. This chapter provides information that will assist the Builder in scheduling construction projects. We will explain some of the basic factors to consider in scheduling the sequence of projects on a deployment, or the sequence of operations on a project. Topics covered include types of schedules, techniques of scheduling, and progress control.

Special attention is given in this instruction to the Critical Path Method (CPM) of scheduling. Basic fundamentals of CPM are discussed, and the method of constructing a CPM diagram is explained. You will note that at appropriate places in our discussion a brief explanation is given as to the meaning of terms used in connection with CPM; for instance, restraint, events, float, and so on. From experience you may already have learned that CPM is a valuable management tool when it comes to planning, scheduling, and controlling construction operations. Therefore, a thorough knowledge of CPM may be to your advantage—both now and later.

SCHEDULING FACTORS

A SCHEDULE is a written plan for carrying out a project, indicating the time when each operation is to begin and the time when it should be completed. Scheduling (also called ECHELONING) is used to plan the sequence of projects on a deployment, and also the sequence of operations on each project. Work schedules show the planned starting and completion time for each operation, thus indicating the time required for each. These schedules are the basis for determining when and how much manpower and equipment are required for each portion of the work, and are therefore the basis for scheduling manpower and equipment, and for determining delivery times for materials not initially shipped with the battalion's equipment and gear. The planned work schedules of the deployment as a whole, and of each project of the deployment, are used in preparing monthly progress and performance reports.

ELEMENTS OF SCHEDULING

The elements used in scheduling work include the work item number, the item description, the unit of measurement (cu yd, sq yd, ton, each, etc.), the quantity of work to be performed, the relation of each item to the whole in terms of work to be performed (such as percentage of the total work required for each item), units of time to be used in the schedule, the starting date, the time required for each item, and the completion date. The elements used in scheduling equipment and manpower are similar to those used for work schedules, but in addition include the number of pieces of equipment and number of men.

TYPES OF SCHEDULES

Work schedules are usually prepared for the deployment as a whole and for each project of the deployment. Manpower and equipment schedules are normally prepared at the same time, because the information they contain is required for preparation of the work schedules. The separate projects of a deployment are scheduled in the deployment schedule; the separate work elements of a project are scheduled in a project schedule.

A typical deployment work schedule is shown in figure 3-1. The deployment will accomplish three projects: the construction of 22 replacement housing units, the laying of 12,600 lin ft of POL (petroleum oil lubricant) system, and the constuction of 28,000 sq yd of road. It is estimated that, of the total work time allotted, 58.7 percent will be required for the replacement housing, 23.9 percent for the POL system, and 17.4 percent for the roads.

DEPLOYMENT WORK SCHEDULE

MCB 12 Location -- Bermuda Year -- 1964 Prepared 1-3-64 by J. Smith

PROJECT NO.	DESCRIPTION	UNIT	QUANTITY	WEIGHTED VALUE [1]	MONTHLY PRODUCTION – EST. AND ACT.							
					Mar	Apr	May	June	July	Aug	Sept	Oct
1	Replacement Housing	Units	22	58.7	10	25	34	43	52	66	85	100
2	POL System	LF	12,600	23.9		2	18	39	58	80	91	100
3	Roads	SY	28,000	17.4	8	31	58	75	100			
	Total Project			100.0	7	21	34	48	62	76	89	100

[1] Weighted value is the percentage of the total man-days allocated to each project.

82.91
Figure 3-1. — Deployment work schedule.

PROJECT WORK SCHEDULE

MCB 12 Location -- Bermuda Year -- 1964 Prepared 1-3-64 by J. Smith
Project -- POL System

ITEM NO.	DESCRIPTION	UNIT	QUANTITY	WEIGHTED VALUE	MONTHLY PRODUCTION – EST. AND ACT.							
					Mar	Apr	May	June	July	Aug	Sept	Oct
2A11	Trenching, Ditching, & Backfilling	CY	2,200	9.1		10	27	44	61	78	95	100
2M2	Install Valves	Each	25	0.9					15	50	80	100
2M4	Construction Valve Pits	Each	10	10.9			10	40	65	90	100	
2M13	Install 12" Pipe	LF	12,600	58.2			20	39	58	77	95	100
2R9	Pump House	Each	1	15.4			15	40	65	85	100	
2Q3	Work not covered above	L/S	1	5.5		5	20	40	55	70	90	100
	Total Project			100.0		1	18	39	60	79	96	100

82.92
Figure 3-2. — Project work schedule.

DEPLOYMENT MANPOWER SCHEDULE

MCB 12 Location -- Bermuda   Year -- 1964   Prepared 1-3-64 by J. Smith
Project -- POL System

PR. NO.	DESCRIPTION		July																														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	Replacement Housing	E	47	47	49	X	49	X	49	41	48	48	48	50	X	46	54	54	50	54	54	X	54	47	47	43	50	47	X	47	47	42	42
		A																															
2	POL System	E	50	50	48	X	48	X	48	56	49	49	49	51	X	51	43	43	47	43	43	X	43	50	50	54	47	50	X	50	50	55	55
		A																															
3	Roads	E	40	40	40	X	40	X	40	40	40	40	40	40	X	40	40	40	40	40	40	X	40	40	40	40	40	40	X	40	40	40	40
		A																															
		E																															
		A																															
		E																															
		A																															
		E																															
		A																															
		E																															
		A																															
Total Men per Day		E	137	137	137	X	137	X	137	137	137	137	137	137	X	137	137	137	137	137	137	X	137	137	137	137	137	137	X	137	137	137	137
		A																															
Total Man-Days per Month		E	3288																														
		A																															

☒ Denotes Sundays and holidays when no work is scheduled.

◪ Denotes Saturdays when half day's work is scheduled.

82.93

Figure 3-3.—Deployment manpower schedule.

Project 1 will begin in March and end in October; project 2 will begin in April and end in October; and project 3 will begin in March and end in July. The estimated percentage of completion of each project for each month is as shown. These monthly figures are used to determine the estimated percentage of completion of the total project (deployment) shown at the bottom of the page. For example: in May, 34 percent of 58.7 percent, 18 percent of 23.9 percent, and 58 percent of 17.4 percent of the work will be accomplished. This amounts to 34 percent of the total work.

Figure 3-2 shows the work schedule for one of the projects shown in figure 3-1. Figure 3-3 shows the deployment manpower schedule for 1 month of the deployment. The total man-days per month figure at the bottom is simply the sum of the total men per day full-day figures, plus half the sum of the total men per half-day figures. Figure 3-4 shows a one-month manpower schedule for one of the projects shown in figure 3-3.

Figure 3-5 shows the equipment schedule for the deployment. The interval during which each item of equipment will be required is indicated by a BAR at the right; for this reason, this type of schedule is called a BAR CHART. In figure 3-6, a similar bar chart shows the 1-month equipment schedule for one of the projects. Figure 3-7 shows a simple tabular type of project work schedule.

TECHNIQUES OF SCHEDULING

In scheduling a project, the first procedure is to list the work elements. Next, determine the construction sequences; obviously, excavating must come before foundation placement, wall construction before the installation of finish door and window frames, subbase and base preparation before paving, and so on. The starting date for the project is, of course, the starting date for the work element which is first in construction sequence.

The time required for each work element is determined by dividing the estimated man-days required by the number of men expected to be assigned to constructing that element. Each work element is scheduled in its proper construction sequence, showing starting and completion dates. Often, of course, it is not economical to wait until one element is finished before starting another. For example: concrete foundations can be started at one end of a building while excavating is still going on at the other end, or paving can begin at one end of a road while grading is still going on at the other.

PROJECT MANPOWER SCHEDULE

MCB 12 Location--Bermuda Year--1964 Prepared 1-3-64 by J. Smith
Project--POL System

IT. NO.	DESCRIPTION		July 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
2A11	Trenching, Ditching, Backfill	E	2	2	2		2		2	2	2	2	2	2		2	2	2	2	2	2		7	7	7	7	7	7		7	7	7	7
		A																															
2M2	Install Valves	E			2		2		2	2													2	2	2								
		A																															
2M4	Construct Valve Pits	E	6	6	6		6		6	10	5	5	5	6		10	6	10	6	6	6		6	6	10	5	5	5		5	5	10	10
		A																															
2M13	Install 12" Pipe	E	26	26	26		26		26	26	26	26	26	26		26	26	26	26	26	26		26	26	26	26	26	26		26	26	26	26
		A																															
2R9	Pump House	E	12	12	12		12		12	12	12	12	12	9		9	9	9	9	9	9		7	7	7	7	10	10		10	10	10	10
		A																															
2Q3	Work not covered above	E	4	4						4	4	4	4	4		4							2	2	2	2	2	2		2	2	2	2
		A																															
		E																															
		A																															
Total men per day		E	50	50	48		48		48	56	49	49	49	[illegible]		51	43	47	43	43	43		50	50	54	47	50	50		50	50	55	55
		A																															
Total man-days per month		E	1181																														
		A																															

82.94
Figure 3-4.—Project manpower schedule.

DEPLOYMENT EQUIPMENT SCHEDULE

MCB 12 Location--Bermuda Year--1964 Prepared 1-3-64 by J. Smith

PROJECT NO. & DESCRIP.	EQUIPMENT	NO. REQ.	Mar	Apr	May	June	July	Aug	Sept	Oct
1 Replacem't Housing	Air Compressor, 210 CFM	1								
	Bulldozer, 113/130 DBHP	1								
	Crawler Crane, 45 Ton	1								
	Mortar Mixer, 6 CF	2								
	Motor Grader, 12' Blade	1								
	Trucks, 2 Ton, Stake	3								
2 POL System	Bulldozer, 113/130 DBHP	1								
	Mortar Mixer, 6 CF	1								
	Motor Crane, 20 Ton	2								
	Trenching Machine	1								
3 Roads	Asphalt Distributor, 24' Width	1								
	Asphalt Finisher, 10'-14' Width	1								
	Asphalt Plant, Complete, 100 Ton	1								
	Bulldozer, 110/113 DBHP	2								
	Motor Grader, 12' Blade	1								
	Scrapers, Self-Propelled, 12 CY	3								
	Tandem Roller, Self-Propelled	1								
	Tractor, Pusher, 113/130 DBHP	1								
	Trucks, 10 Ton, Dump	3								
	Vibrating Compactor	1								
All Projects	Concrete Batch Plant, Complete	1								
	Transit-Mix Trucks, 5½ CY	3								

82.95
Figure 3-5.—Deployment equipment schedule.

PROJECT EQUIPMENT SCHEDULE

MCB 12 Location -- Bermuda Year -- 1964 Prepared 1-3-64 by J. Smith
Project -- POL System

ITEM NO. & DESCRIPTION	EQUIPMENT	NO. REQ.	Mar	Apr	May	June	July	Aug	Sept	Oct
2A11 Trench & BF	Trenching Machine	1								
	Bulldozer, 130 DBHP	1								
2M2 Inst Valves	Motor Crane, 20 Ton	1								
			Work in conjunction with 12" pipe							
2M13 Inst 12" Pipe	Motor Crane, 20 Ton	2								
	Bulldozer, 130 DBHP	1								
2R9 Pump House	Motor Crane, 20 Ton	1								
	Mortar Mixer, 6 CF	1								

82.96
Figure 3-6.— Project equipment schedule.

PROJECT WORK SCHEDULE

MCB 12 Location -- Bermuda Year -- 1964 Prepared 1-3-64 by J. Smith
Project -- POL System

ITEM NO.	DESCRIPTION	UNIT	QUANTITY	WEIGHTED VALUE	ESTIMATED		ACTUAL	
					START	FINISH	START	FINISH
2A11	Trenching, Ditching, & Backfilling	CY	2200	9.1	4-16-64	10-18-64		
2M2	Install Valves	Each	25	0.9	7-16-64	10-16-64		
2M4	Construct Valve Pits	Each	10	10.9	5-14-64	9-20-64		
2M13	Install 12" Pipe	LF	12,600	58.2	4-30-64	10-16-64		
2R9	Pump House	Each	1	15.4	5-14-64	9-29-64		
2Q3	Work not covered above	L/S	1	5.5	4-16-64	10-18-64		
	Total Project			100.0	4-16-64	10-18-64		

82.97
Figure 3-7.— Project work schedule.

PROGRESS CONTROL

Progress control is exercised by:

1. Measuring actual production against planned production.
2. Determining causes of discrepancies, if there are any.
3. Taking remedial action to correct deficiencies in production and to balance activities in order to attain overall objectives.

Reporting Progress

Work accomplished should be reported on daily labor reports. However, in some types of work, it

is more convenient to report work quantities as portions are completed, rather than to attempt to report partial completion of portions. For example: if 2000 square feet of contact surface (sfcs) wall forms are required for a section of concrete wall, it is difficult to estimate partial progress of the formwork, and no report is usually made until it is completed, ready for concrete placing.

Items suitable for daily reporting are those which may reasonably be expected to show a fairly steady production rate per man-hour, such as laying concrete block, placing concrete or asphalt paving, or the excavating and/or hauling of large quantities of cut and fill. For such items, daily reports provide a continuous, running check on progress.

A daily report should show the man-hours expended on each work element. Preparation of weekly or monthly reports is accomplished by recording daily reports in ledger form and totaling for a week or month.

Monthly progress reports are usually made in narrative form, with a progress chart (explained later) included in the report. Major problems affecting progress should be described, and any unusual construction methods should be reported in detail, with sketches included if necessary. If progress is behind schedule, the report should describe what measures are being taken to bring it back on schedule, or explain why the completion date cannot be met and what extension of time is needed for completion.

Charting Progress

A common way of charting progress is to insert percentages of actual work completed in spaces left adjacent to the figures for estimated completion percentages on work schedules.

THE CRITICAL—PATH METHOD

In recent years, a new system of project planning, scheduling, and control, called the CRITICAL-PATH METHOD (CPM), has come into existence and widespread use in the construction industry. The object of CPM is to combine all the information relevant to the planning and scheduling of project functions into a single master plan—a plan that coordinates all of the many different efforts required to accomplish a single objective, that shows the interrelationships of all of these efforts, that shows which efforts are critical to timely completion, and hence promotes the most efficient use of equipment and manpower.

The Critical Path Method of scheduling was one of the outgrowths of the Program Evaluation Review Technique (PERT) developed in the Special Projects Office, BuWeps, Navy Department. An interesting feature of this system was the method of planning the construction of and predicting the delivery of new missiles and missile-firing submarines which were completed years ahead of the originally scheduled time.

While CPM has been most widely applied in the construction field, other possible applications are almost unlimited. A shop supervisor, for instance, may often find CPM useful in planning work to obtain most economical manpower utilization.

There is a lot to know about CPM and you may not find all the information you need on the subject in this training course. Sufficient coverage is provided, however, to assist you in interpreting critical path schedules drawn up for jobs under your supervision, as well as in developing critical path schedules for future construction projects.

ARROW DIAGRAMMING

Instead of using several sets of bar chart schedules, difficult to coordinate with each other, CPM represents each work element by an arrow on a single chart. The tail of the arrow represents the start of the element; the head represents the finish. When the arrows are related to the time required for each element, the time length of the longest path through the diagram equals the total time required to complete the project. Shorter paths are followed by arrows which indicate elements that may be performed simultaneously with other elements. However, the length of the arrow has no relation to the time it takes to do the job. Every element on the longest path is CRITICAL, in that any delay in one of these delays the whole project. An element on a shorter path is noncritical, in that a delay in one of these (within limits, of course) will not delay the whole project.

CPM PLANNING

Two of the basic ground rules of CPM are that planning and scheduling are considered to be separate operations, with planning always preceding scheduling.

Analysis of Project

First, the project is planned without any consideration of time or the availability of resources. This planning consists of analyzing the project, breaking it into work elements, and

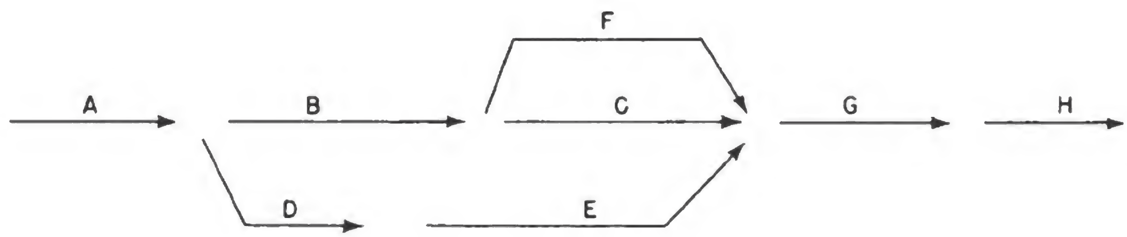


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Figure 3-8.—Arrow diagram for critical path method.

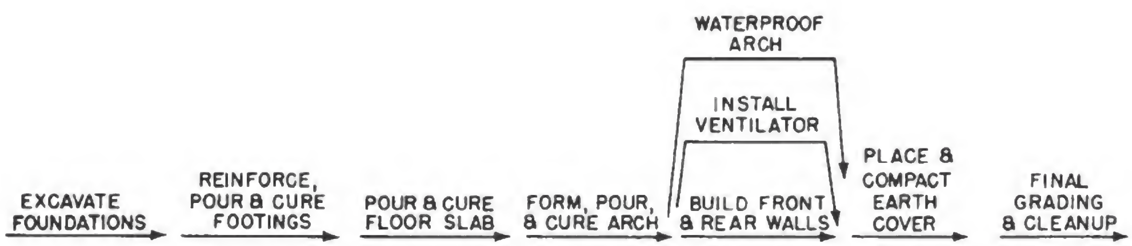

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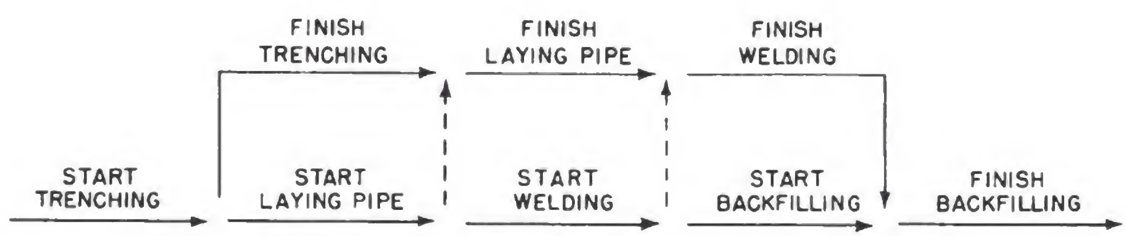
Figure 3-9.—Work elements in a project for construction of an arch-type high explosive magazine.



82.100
Figure 3-10.—Arrow diagram showing parallel work elements.

arranging these elements in the ARROW DIAGRAM which becomes the working model of the project. As each work element is defined, three questions are considered, as follows:

1. What element must immediately precede this element?
2. What element must immediately follow this element?
3. What other elements, if any, can be done simultaneously with this element?

Development of Arrow Diagram

An arrow is drawn for each work element. The head of the arrow represents the completion of the element; the tail represents the beginning. The tail is connected to the heads of all arrows representing work elements which must be completed immediately before the element under consideration can begin. The head is connected to the tails of all arrows representing elements which cannot begin until the element under consideration is completed.

Observe, for example, figure 3-8. In this diagram, job A must be completed before jobs B and D can start. When job B has been completed, jobs F and C can start. Jobs E, C, and F must be completed before job G can begin. Finally, job H can begin when job G is finished.

Figure 3-9 shows an arrow diagram for a project consisting of the construction of an arch-type high explosives magazine. The project contains the following work elements:

Excavate foundations
Reinforce, pour, and cure footings
Form, reinforce, pour, and cure the arch
Form, reinforce, pour, and cure front and rear walls
Waterproof top side of arch
Install ventilator
Place and compact magazine earth cover
Perform final grading and cleanup

Obviously, the foundations must be excavated before anything else can be done, so you draw an arrow at the left and label it "Excavate Foundations." When the foundations are excavated, the footings can be poured; therefore, the tail of an arrow marked "Reinforce, Pour, and Cure Footings" is connected to the head of the previous arrow. When the footings have set and cured, the floor slab can be poured; therefore, the tail of an arrow marked "Pour & Cure Floor Slab" is connected to the head of the footings arrow. When the floor slab has set and cured, the arch can be formed, poured, and cured; therefore, the tail of an arrow marked "Form, Pour, & Cure Arch" is connected to the head of the floor slab arrow.

With the arch cured, the front and rear walls can be built. Simultaneously with this operation, two others can be carried on: installing the ventilator, and waterproofing the arch. Since all three simultaneous elements must be completed before anything else can be done, however, the heads of the three arrows all converge at the same point. When all three jobs are done, the earth cover can be placed and compacted, and then the final grading and cleanup done.

Parallel Work Elements

Suppose a project consists of laying a weld-joined pipeline from A to B. Work elements might be: (1) trenching, (2) pipe laying, (3) welding, and (4) backfilling. Obviously, however, it would not be economical to complete one of these before starting the next. As soon as an appreciable amount of trenching is done, pipe laying can begin; as soon as a little pipe is laid, welding can begin; and so on until all four elements are being performed simultaneously. However, no one element can be COMPLETED until the previous element has been completed. Welding, for example, cannot be completed until all the pipe has been laid.

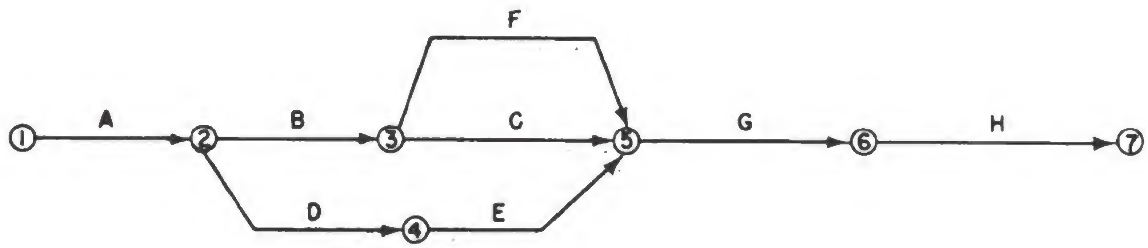
In a case of this kind, you break each work element arrow into two parts, one showing the start and the other the finish, as shown in figure 3-10.

Events and Event Numbering

The points where arrows connect are called EVENTS; these points are points in time, marking the time of completion of some work and the time of beginning of other work. Events are numbered from left to right through the diagram. Obviously, the event number at the head of an arrow must be larger than the event number at the tail.

Figure 3-11 shows an arrow diagram with events numbered correctly. It would be incorrect to label the event at the end of job C with the number 4 and that at the end of job D with 5. If you did this, the event number at the beginning of job E would be 5 and that at the end 4—a case in which the number at the tail of the arrow would be larger that that at the head.

Each work element is identified by the event numbers on its arrow. For example: job B in figure 3-11 would be identified as job (2,3).



82.101
Figure 3-11.—Events and event numbering.

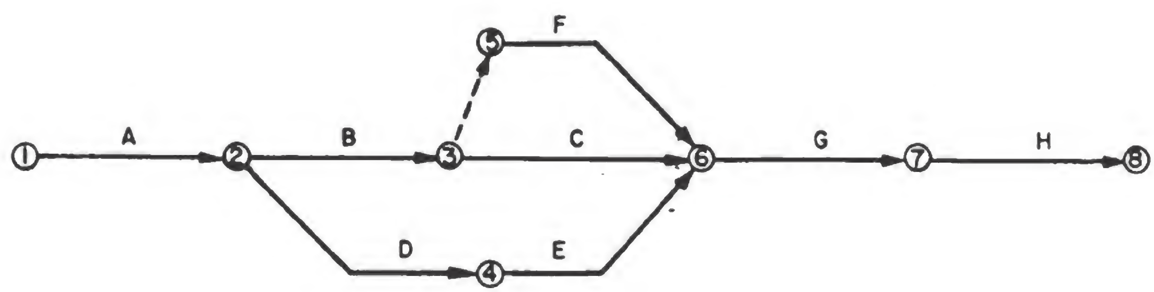


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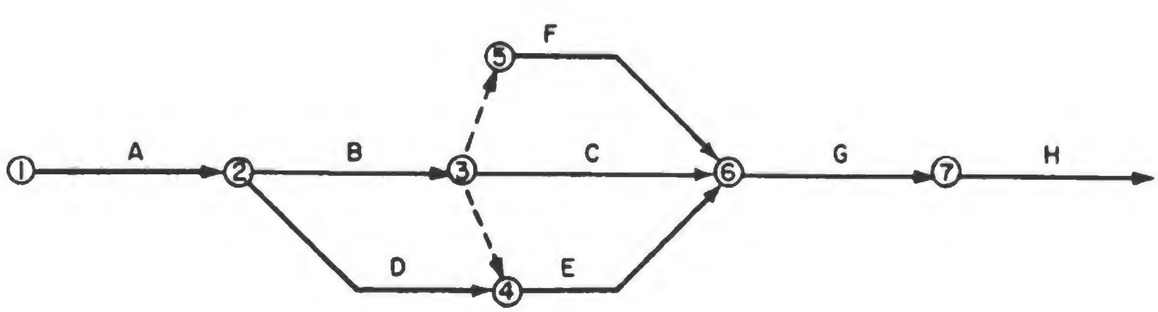
Figure 3-12.—Dummy arrow.



82.103
Figure 3-13.—Dummy arrow (3,4) indicates dependency.

Use of Dummy Arrows

There may be two or more jobs going on simultaneously, in which case, in the absence of some special device, the arrows for these jobs would have the same event numbers. To avoid this, DUMMY arrows and ARTIFICIAL event numbers are used as shown in figure 3-12. The dotted dummy arrow extending from 3 to 5 and the artificial event number 5 have been introduced so that job F will not have the same event numbers as job C.

Dependency

If job B cannot start until job A is completed, job B is said to be DEPENDENT on job A. Dummy arrows may be used to indicate this relationship. The dummy arrow from 3 to 4 in figure 3-13 indicates that job E; or job (4,6), cannot begin until job B, or job (2,3), is completed. The fact that the tail of the arrow for job E lies at the head of the arrow for job D already indicates that E cannot start until D is completed. The addition of the dummy arrow indicates that before E can start, B must be completed as well.

Restraint

A condition which is not a work element, but which must be fulfilled before a work element can begin, is called a RESTRAINT. Suppose, for example, that a bulldozer is required before a certain element can begin. Requisitioning the bulldozer is a project work element. Delivery, however, is not a project work element, but a restraint, or condition which must be fulfilled before the element involving the bulldozer can begin. Figure 3-14 shows how a dummy arrow is used to indicate a restraint.

Final Check of Diagram

The completion of the arrow diagram ends the planning stage of CPM planning and scheduling. A word of caution: if you are uncertain as to the sequence of work elements, find out what the proper sequence is before you attempt the diagram. Before you assign event numbers, go over it carefully and make sure that the sequence is correct, and that all necessary dummies for artificial events and restraints are shown. Do not, however, use any unnecessary dummies; these only confuse the diagram.

CPM SCHEDULING

When a project has been planned on an arrow diagram, the next step is to schedule it—that is, to place it on a working timetable. When this has been done, it will be possible to determine when each of the various jobs must be performed, when deliveries must take place, how much (if any) spare time there is for each job, and when completion of the whole operation may be expected. It will also be possible to determine which jobs are critical. and to what extent a delay in one job will affect succeeding jobs.

Work Element Durations

You begin scheduling by marking beside each job arrow the expected length of time that job take, as shown in figure 3-15. In this figure, dummy (3,5) is simply a device introduced to give job F distinctive event numbers, and dummy (3,4) is introduced to show that job E cannot start until job B is completed. Therefore, these dummies have no duration times. A dummy indicating a restraint, however, would be marked with the time required for perforamance of the restraint.

Earliest Event Times

The earliest time at which an event can occur is the sum of the durations of the work elements on the LONGEST PATH leading up to the event. This time is entered in a rectangular box next to the event on the arrow diagram, as shown in figure 3-16.

The times shown are, of course, project times—that is, successive WORKING days, not successive calendar days, reckoned from 0 at the tail and of the first work element arrow. The duration of the first job in figure 3-16 is 2 days; therefore, event 2 occurs at project time 2. The time for event 3 is the sum of the duration times of (1,2) and (2,3), or 24. However, there are two paths leading to event 4: one from 1 through 2 for a total of 17, the other from 1 through 2 and 3 for a total of 24. Following the rule of selecting the longest path, the event time for event 4 is 24. Similarly, three paths lead to event 6, and the longest (from 1 through 2 and 3) is selected, giving an event time for 6 of 37.

Latest Event Times

You also need to know the latest time at which an event can occur. To determine this, you begin at the end of the project and work backward. To

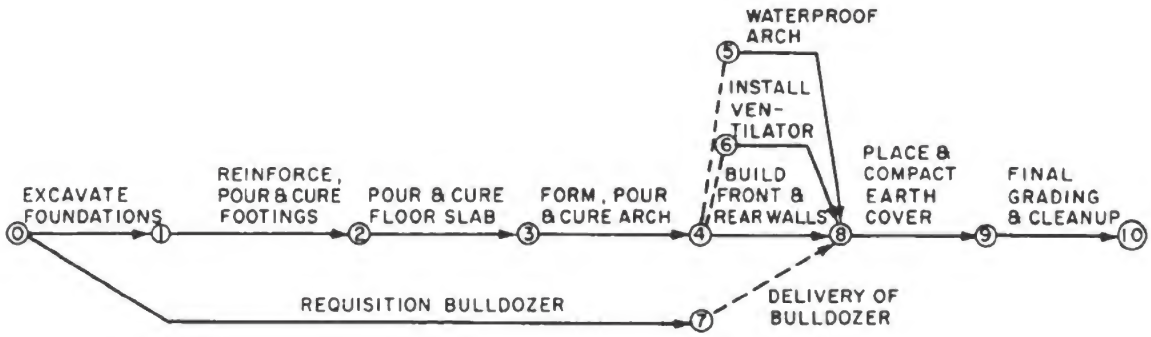


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Figure 3-14. — Dummy arrow indicating restraint.

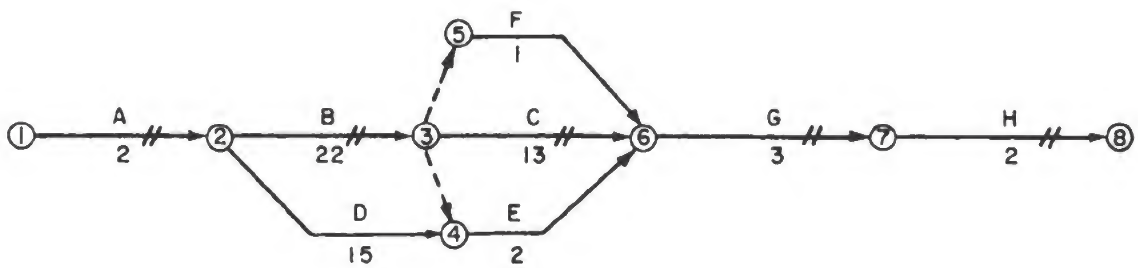

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Figure 3-15. — Job durations on arrow diagram.

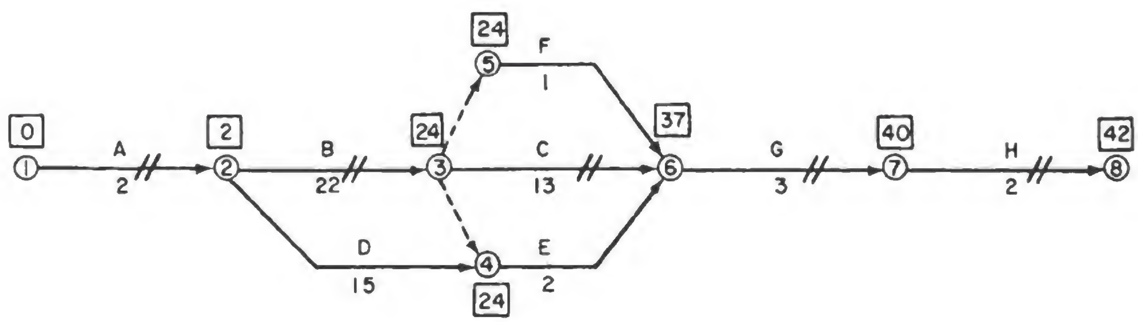

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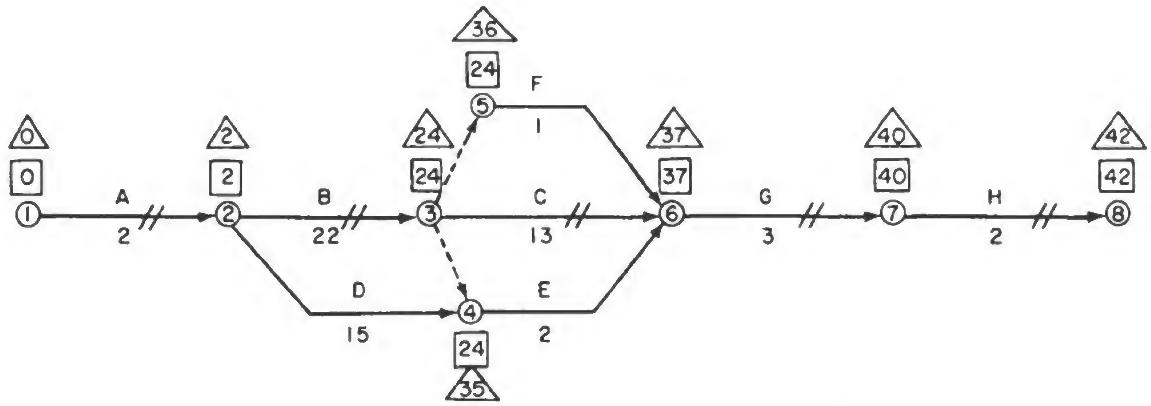
Figure 3-16. — Earliest event times on arrow diagram.



82.107
Figure 3-17.—Latest event times on arrow diagram.

calculate the latest time at which an event can occur, subtract the duration of the immediately following job from the immediately following latest event time. The latest event time is entered in a small triangle adjacent to the rectangle containing the earliest event time, as shown in figure 3-17.

In that figure, the latest event times for events 6, 7, and 8 are the same as the earliest event times. This follows from application of the rule given. The latest event time for event 7, for example, equals the latest event time for event 8, which is 42, minus the duration of (7,8), which is 2. The remainder is 40.

However, the latest event time for even 4 equals the latest event time for 6, which is 37, minus the duration of (4,6), which is 2, or 35. The latest event time for event 5 equals the latest event time for 6, which is 37, minus the duration of (5,6), which is 1, or 36. The latest event time for 3 equals the latest event time for 6, which is 37, minus the duration of (3,6), which is 13, or 24.

Note that for an event on the critical path the earliest event time and the latest event time are the same; it is only for events not on the critical path that these event times differ. It follows that identical earliest and latest event times are another means of identifying job arrows on the critical path. For a job to be critical, both of the following conditions must exist:

1. At each end of the arrow, the number in the rectangle (earliest event time) and that in the circle (latest event time) must be the same.
2. The job duration must equal the difference between a number at the head of the arrow and a number at the tail of the arrow.

Determining Critical Path

When the job durations have been placed on the arrow diagram, the critical path can be determined. The critical path is the LONGEST path through the diagram, in terms of time. In figure 3-15, there are three possible paths through the diagram: the path from 1 through 2, 4, 6, 7, and 8, which totals 24 days; the path from 1 through 2, 3, 5, 6, 7, and 8, which totals 30 days. The middle path is the longest; therefore, this is the critical path. It is indicated by marking the arrows with small double slants, as shown in figure 3-15.

This path represents the normal duration of the project. Every work element on the path is critical to the completion of the project in 42 days. If any one of these elements is delayed, the completion of the whole project will be delayed.

EARLIEST AND LATEST JOB START AND FINISH TIMES

Figure 3-18 shows a fully developed arrow diagram for the project of building an arch-type magazine, with all work elements included, and with earliest and latest event times inscribed. With earliest and latest event times established, earliest and latest starts and finishes for work elements can be determined.

In figure 3-18, for example, what are the latest and the earliest days on which waterproofing of the topside of the arch can be started, and what are the earliest and latest days on which the installation of the ventilator can be started?

Before either of these jobs can begin, the stripping of the arch forms, which is job (9,10), must be completed. This job is on the critical

path, and it will be completed at event time 24. The waterproofing of the arch and the installation of the ventilator must be completed by event time 37, if the project is not to be delayed.

The waterproofing is a 2-day job. It can begin as early as day 25 (day of completion of stripping of arch forms plus 1), or as late as day 36 (final deadline for completion minus 2 plus 1). It can be completed as early as day 26 or as late as day 37. Similarly, the installation of the ventilator can begin as early as day 25 or as late as day 37, and can end as early as day 25 or as late as day 37.

The rules for calculating start and finish days for a work element, then, are as follows:

Earliest start day: earliest event time at the tail of the arrow plus 1.
Earliest finish day: earliest start time plus job duration.
Latest start day: latest event time at the head of the arrow minus job duration plus 1.
Latest finish day: latest event time at the head of the arrow.

To calculate earliest finish days, you work from left to right on the diagram, adding job durations to earliest event times. To calculate latest start times, you work from right to left, subtracting job duration from preceding latest event time.

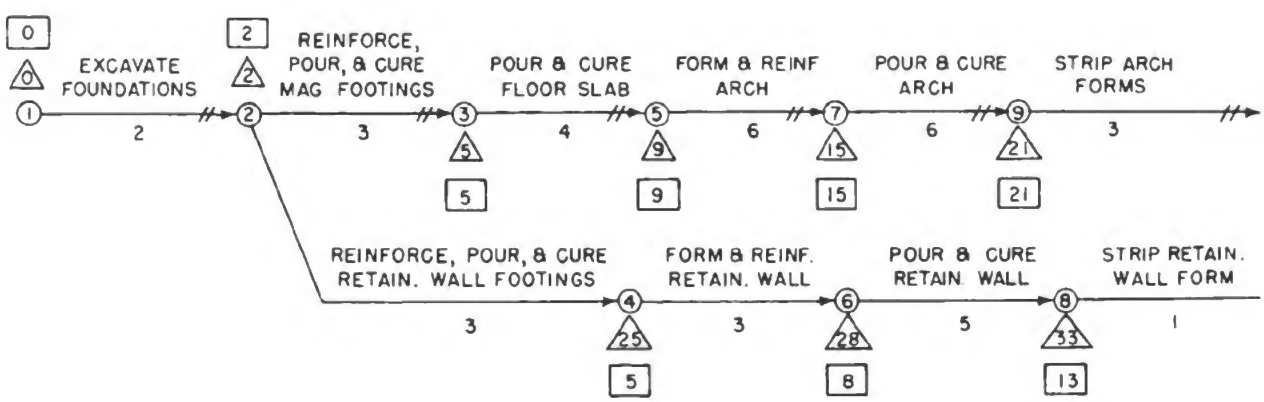
Results are entered in a schedule as shown in figure 3-19. This schedule assumes that all jobs will be started as early as possible.

CONCEPT OF FLOAT

The spare time available to perform a task such as the installation of the ventilator in figure 3-18 is called FLOAT. Properly controlled, the manipulation of float is valuable in determining the most efficient use of manpower, equipment, and materials. The existence of float allows latitude in the timing of the jobs with which it is associated. On the other hand, a job having no float is inflexible; it must start and end precisely at specific times, or the completion of the project will be affected.

Rule for Calculating Float

In figure 3-18, the installation of the ventilator has 12 days of float, because it is a 1-day job and there are 13 days available in which it may be performed. Similarly, the waterproofing job in the same figure has 11 days of float. To calculate float, subtract both the duration and the earliest event time at the tail of the arrow from the latest event time at the head of the arrow. For job (6,8),



82.108.2
Figure 3-18. – Diagram of high-explosives magazine.

for example, the float comes to 33 - 8 - 5, or 20.

Each of the noncritical jobs along the path from event 2 to event 11 has 20 days of float when considered independently. However, there are only 20 days of float available for the whole chain, calculated as follows: 34 - 2 - (3 + 3 + 5 + 1) = 34 - 2 - 12 = 20. Fundamentally, the reason is the fact that when float is calculated independently for each separate job, it is assumed that all the preceding jobs were started as early as possible. However, as soon as any float is used, the float available to subsequent jobs is correspondingly reduced.

Suppose, for example, that job (4,6) was delayed for 3 days. The succeeding job (6,8) would have 3 days added to its earliest event time and subtracted from its float. The float for job (6,8) would then be 33 - 11 - 5, or 17.

Use of Float in Allocation of Manpower and Equipment

In the construction of the high-explosives magazine diagrammed in figure 3-18, there are three jobs of form stripping to be done. The stripping of the arch is critical, and must be performed between event times 21 and 24. Similarly, the stripping of the front and rear wall forms must be done between day 32 and day 34. However, the stripping of the retaining wall forms is a 1-day job which may be done at any time between event time 13 and event time 34. Obviously, the crew should be scheduled to strip the retaining wall at a time when they are not busy with the arch or front and rear wall forms. Similarly, the pouring and curing should be scheduled so as to take advantage of the float in job (6,8). By starting job (6,8) one day after its earliest start time, it can be performed concurrently with job (5,7). Thus, by using up a day of float, more efficient use is made of crew and equipment.

Adjustment of Float

Earliest and latest event times shown in the arrow diagram (fig. 3-18) were changed to reflect the days dropped out as a result of weekend curing. A check was then made to ensure that the critical path was still the same, since shortening the original critical path might cause another to take its place. Next, the float was recalculated, and the new float values were entered in the timetable (fig. 3-20). Notice that on the timetable job (11,18) and job (17, 18), both of which consist of placing and compacting fill (see fig. 3-18), are scheduled about a month apart. Since job (11, 18) shows 20 days of float, however, and since the same equipment will be used for both jobs, the float for job (11, 18)

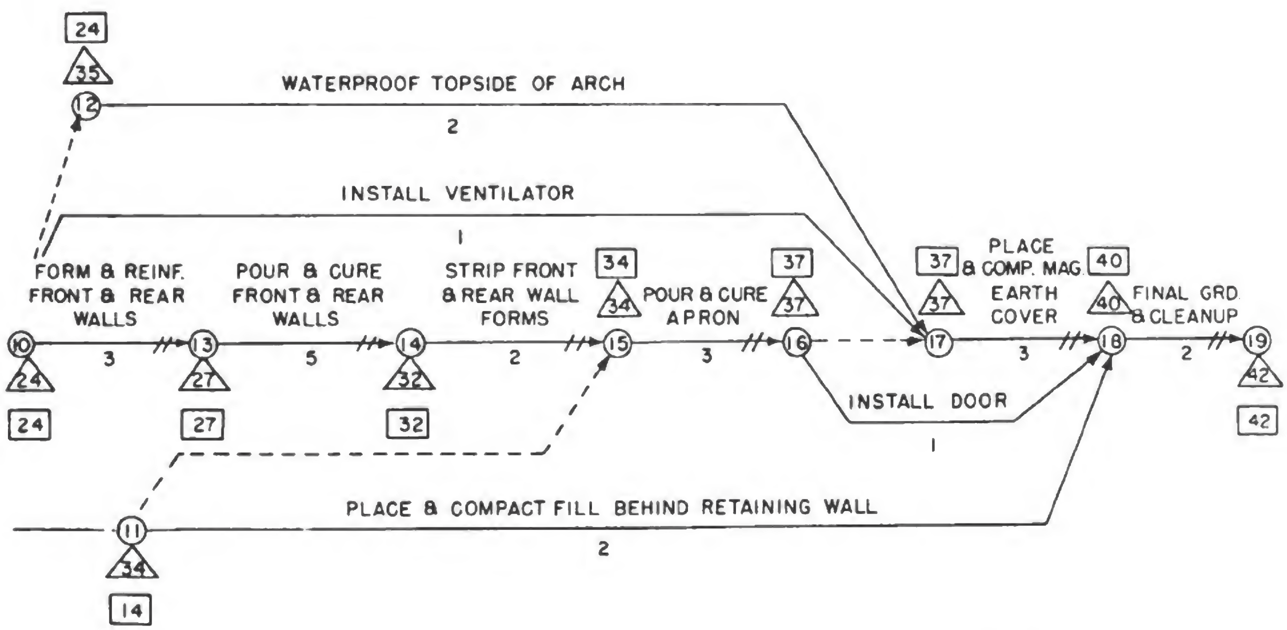


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Figure 3-18.—Diagram of high-explosives magazine—continued.

JOB	PROJECT DAY				REMARKS
	START		FINISH		
	EARLIEST	LATEST	EARLIEST	LATEST	
(1, 2)	1	1	2	2	critical
(2, 3)	3	3	5	5	critical
(2, 4)	3	23	5	25	
(3, 5)	6	6	9	9	critical
(4, 6)	6	26	8	28	
(5, 7)	10	10	15	15	critical
(6, 8)	9	29	13	33	
(7, 9)	16	16	21	21	critical
(8, 11)	14	34	14	34	
(9, 10)	22	22	24	24	critical
(10, 12)	0	0	0	0	dummy
(10, 13)	25	25	27	27	critical
(10, 17)	25	37	25	37	
(11, 15)	0	0	0	0	dummy
(11, 18)	15	39	16	40	
(12, 17)	25	36	26	37	
(13, 14)	28	28	32	32	critical
(14, 15)	33	33	34	34	critical
(15, 16)	35	35	37	37	critical
(16, 17)	0	0	0	0	dummy
(16, 18)	38	40	38	40	
(17, 18)	38	38	40	40	critical
(18, 19)	41	41	42	42	critical

82.109

Figure 3-19.—Project schedule from CPM arrow diagram shown in figure 3-18.

will probably be used to schedule this job to end the day before job (17, 18) begins.

PREPARING A TIMETABLE

After the arrow diagram has been completed and the float has been calculated, a timetable like the one shown in figure 3-20 can be prepared. This is a timetable derived from the arrow diagram shown in figure 3-18. Obviously, project day 1 falls on 1 March, a Thursday. No work is done on Saturdays or Sundays; therefore, though project days 1 and 2 fall on Thursday and Friday, 1 and 2 March, project day 3 falls on Monday, 5 March. As you can see, however, Saturdays and Sundays are included in the calendar when they can be utilized as curing time for concrete jobs. When this is done, such a Saturday or Sunday becomes a project day, and if the day relates to a job on the critical path, the effect is to gain time by cutting a day from the schedule. In figure 3-20, 5 days were cut from the critical path by scheduling concrete work so that curing could occur on weekends.

For example: job (3,5) consisted of placing and curing the magazine footings. It was started on Thursday, so that curing could be scheduled for Saturday and Sunday. Since this job was on the critical path, the use of Saturday and Sunday for curing cut 2 days from the schedule.

JOB	PROJECT DAYS		CALENDAR DAYS		FLOAT
	START	DURATION	START	FINISH	
(1, 2)	1	2	March 1, Thurs.	March 2, Fri.	0
(2, 3)	3	3	March 5, Mon.	March 7, Wed.	0
(2, 4)	3	3	March 5, Mon.	March 7, Wed.	16 [2]
(3, 5) [1]	6	4	March 8, Thurs.	March 11, Sun.	0
(4, 6)	6	3	March 8, Thurs.	March 12, Mon.	16 [2]
(5, 7)	10	6	March 12, Mon.	March 19, Mon.	0
(6, 8)	9	5	March 13, Tues.	March 17, Sat.	16 [2]
(7, 9)	16	6	March 20, Tues.	March 25, Sun.	0
(8, 11)	14	1	March 19, Mon.	March 19, Mon.	16 [2]
(9, 10)	22	3	March 26, Mon.	March 28, Wed.	0
(10, 12)	–	0	–	–	0
(10, 13)	25	3	March 29, Thurs.	April 2, Mon.	0
(10, 17)	25	1	March 29, Thurs.	March 29, Thurs.	11 [2]
(11, 15)	–	0	–	–	0
(11, 18)	15	2	March 20, Tues.	March 21, Wed.	20 [2]
(12, 17)	25	2	March 29, Thurs.	March 30, Fri.	10 [2]
(13, 14) [1]	28	5	April 3, Tues.	April 7, Sat.	0
(14, 15)	33	2	April 9, Mon.	April 10, Tues.	0
(15, 16)	35	3	April 11, Wed.	April 13, Fri.	0
(16, 17)	—	0	—	—	0
(16, 18)	38	1	April 16, Mon.	April 16, Mon.	2
(17, 18)	38	3	April 16, Mon.	April 18, Wed.	0
(18, 19)	41	2	April 19, Thurs.	April 20, Fri.	0

[1] Curing scheduled for weekend.
[2] Adjusted to reflect weekend curing.

82.110
Figure 3-20.—Timetable from arrow diagram shown in figure 3-18.

CHAPTER 4

EXTERIOR AND INTERIOR FINISH

The principal parts of exterior and interior finish (cornice trim, roof covering, water table, corner boards, wall covering, stairs, baseboards, and the like) are explained in Builder 3 & 2. In this chapter we are primarily concerned with the fabrication of doors and window frames. We will explain the procedures and techniques involved in fabricating both outside and inside door frames. Procedures applicable to the fabrication of outside and inside window frames will also be explained. In conclusion, this chapter provides some useful pointers that will aid you in supervising various operations dealing with exterior and interior finish carpentry.

OUTSIDE DOOR FRAMES

Door openings in exterior walls generally require double headers. Regular studs normally are placed 16 in. O.C. and extra studs are used at the sides of all such openings. Openings should allow 1/2 inch between the back of the jamb and framing member for the plumbing and leveling of jambs.

Before the exterior covering is placed on the outside walls, the door openings are prepared for the frames. To prepare the openings, square off any uneven pieces of sheathing and apply heavy building paper around the sides and top. Since the sill must be worked into a portion of the rough flooring, no paper is put on the floor. Position the paper from a point even with the inside portion of the stud to a point about 6 inches on the sheathed walls and tack it down with small nails.

DOOR FRAME CONSTRUCTION

The principal parts of a door frame are shown in figure 4-1.

Construction information on an outside door frame is usually given in details like those shown in figure 4-2 and in the left-hand view of figure 4-3. In the type of frame shown in figure 4-2, the door jambs are rabbeted to a depth of 1/2 in. to prevent the door from swinging right through the frame when it is closed. In other types of frames the jambs are not rabbeted, but the same function is performed by strips of wood, nailed to the inner faces of the jambs and called a STOP.

The starting point for door frame layout calculations is the dimensions of the door, as given on the door schedule. The side jambs of an outside door are cut to the height of the door, less the depth of the head jamb rabbet (if any), plus the sum of the following:

1. The thickness of the sill, plus the sill BEVEL ALLOWANCE (a sill bevel allowance is indicated in fig. 4-1).
2. The thickness of the THRESHOLD, if any. The distinction between the sill and the threshold is apparent in the left-hand view of figure 4-3.
3. The thickness of the head jamb.
4. The height of the side-jamb lugs (see middle view fig. 4-1).

The head jamb is cut to the width of the door, less the combined widths of the side-jamb rabbets (if any), plus the combined widths of the head-jamb dadoes (see middle view fig. 4-1).

The casing layout depends on the manner in which the side casings are joined to the head casing at the corners (miter or end-butt joints). The casings are usually set back about 1/2 in. from the faces of the jambs. The best way to lay out casings is to assemble the jambs and sill first, then measure off the lengths of the casings in the places where they go.

After the head-jamb and sill dadoes have been cut in the side jambs, assemble the jambs and sill as follows: Set the head jamb vertically in the bench vise, at a height which makes it possible for you to rest the side jamb on the bench when the two are joined together. Lay the side

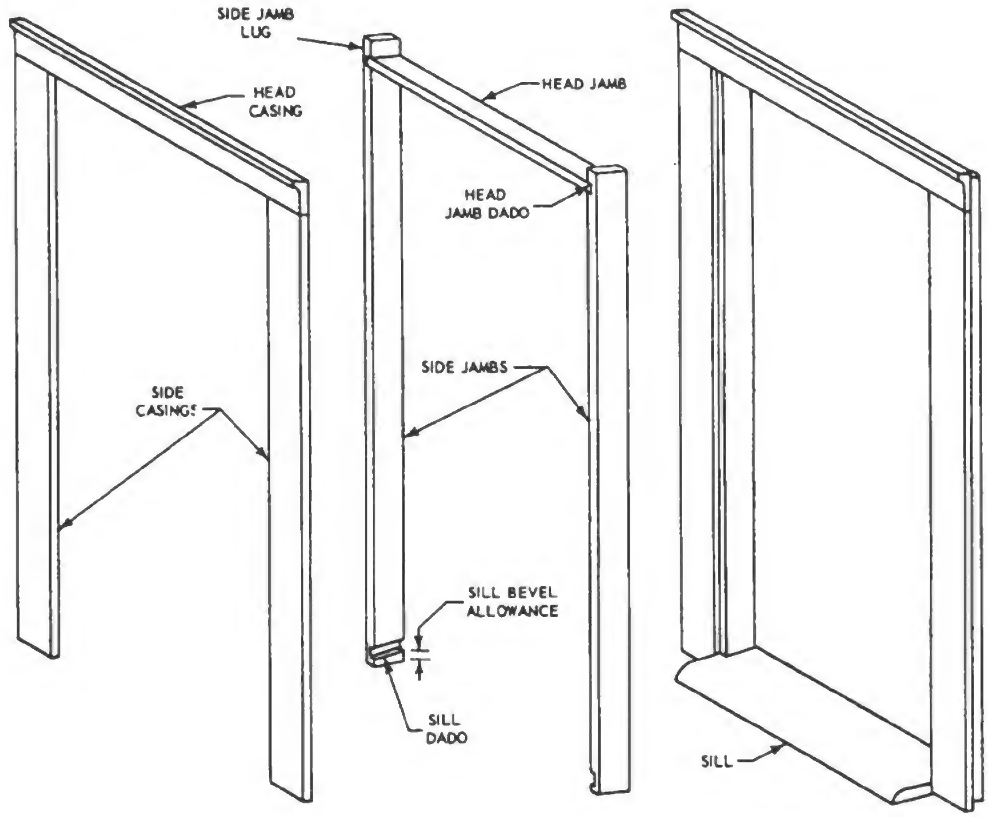

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Figure 4-1.—Principal parts of a door frame.

jamb on the bench and fit the dado over the end of the head jamb. Fasten the joint with three 8-penny common nails, driven through the side jamb into the end of the head jamb.

Take the head jamb out of the vise, set the sill vertically in the vise, and attach the side jamb to the sill in the same manner. Set the three joined pieces on the deck with the side jamb down, fit the other side jamb to the head jamb and sill, and nail together. Square the frame carefully with a framing square, and nail a pair of diagonal braces across the back edges of the side jambs to hold it square. Measure off, lay out, and nail the jambs in place. Cut the outside casings, and nail them to the front edges of the jambs with 10-penny casing nails 16 in. O.C.

SETTING AN OUTSIDE DOOR FRAME

In balloon-frame construction a SILL HEADER must be framed between the trimmer studs, flush with the outer faces of the studs, to support the sill and the lower ends of the side jambs, as shown in figure 4-3. In platform-frame construction, the sill and the bottom ends of the side jambs rest on the subflooring.

An outside door frame is plumbed in the rough opening with thin shingle-type wedges, 5 to each side, inserted at intervals up the side jambs between the jambs and the trimmer studs. Before the assembled frame is set in the rough opening, a strip of building paper 10 or 12 in. wide should be tacked to the sheathing around the rough opening.

Place the frame in the rough opening and set a brace against it to hold it in place during the process of plumbing and wedging. Place a level on the sill, and if the sill is not level, wedge it up as necessary until it is. Insert the side jamb wedges, and drive the corresponding wedges on each jamb part way alternately, until the space between side jamb and trimmer stud is the same on both sides of the frame. Then drive a 16-penny casing nail through the

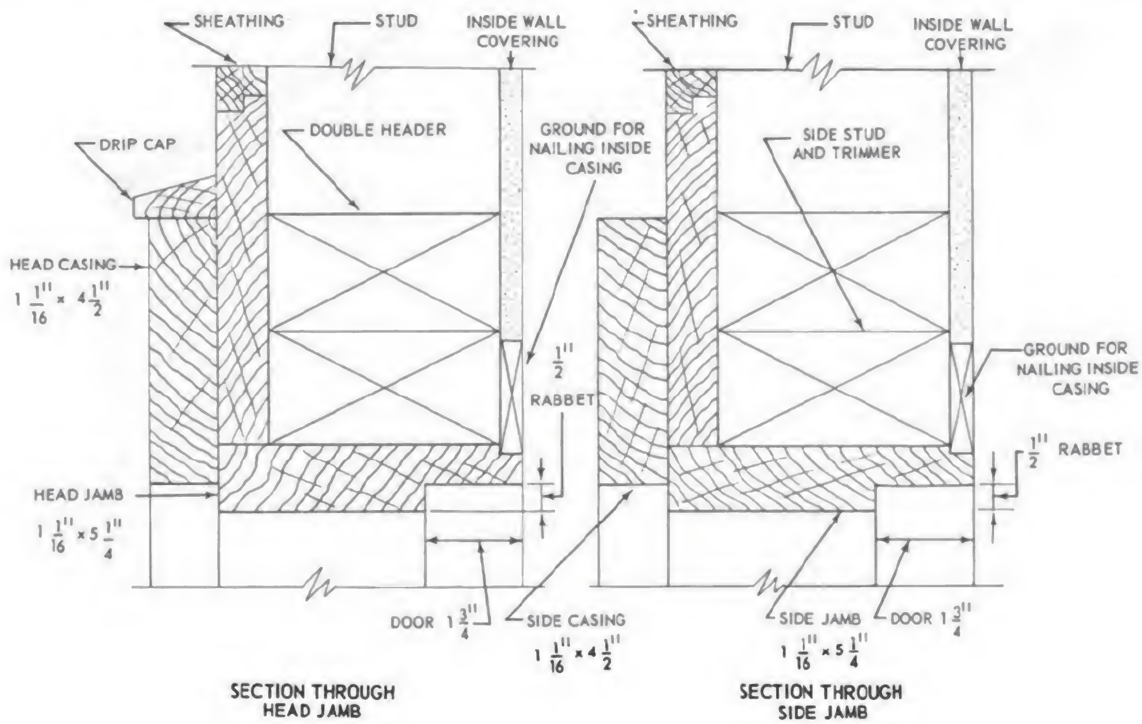

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Figure 4-2. — Outside-door frame details.

side casing and into the trimmer stud on both side casings, near the bottom of the door, to hold the sill in level position. Drive the nails only part way, however; do not drive any nails all the way in until all nails have been placed and a final check has been made for levelness and plumbness.

Next place the level against one of the side jambs, and drive the upper wedges on that side so as to bring the jamb plumb and true. Repeat the process on the other side. Make a final all-around check for levelness and plumbness; then fasten the frame in place with 16-penny casing nails, set 3/4 in. from the outer edges of the casings 16 in. O.C., and driven through the casings into the trimmer studs and the rough-frame door header. Set all nails with a nail set.

OUTSIDE WINDOW FRAMES

Windows are generally classified as sliding, double-hung, and casement. All windows, whatever the type, consist essentially of two parts, the frame and the sash. The frame is made up of four basic parts: the head, the jamb (two), and the sill. Good construction around the window frame is essential to good building. Where openings are provided, studding must be cut away and its equivalent strength replaced by doubling the studs on each side of the opening to form trimmers and inserting a header at the top. At the bottom of the opening, the bottom header or rough sill is inserted.

The installation of finish outside-window frames is usually going on simultaneously with the roof covering. These frames may be ordered ready-made from a civilian millworking plant, and delivered to the site either assembled or K.D. (meaning "knocked down," or in the shape of parts to be assembled at the site). However, the frames may be fabricated in the battalion carpenter shop.

WINDOW FRAME CONSTRUCTION

A finish frame for a casement, transom, or jalousie window is made and set much like a door frame. A frame for a double-hung window, however, is somewhat more complicated.

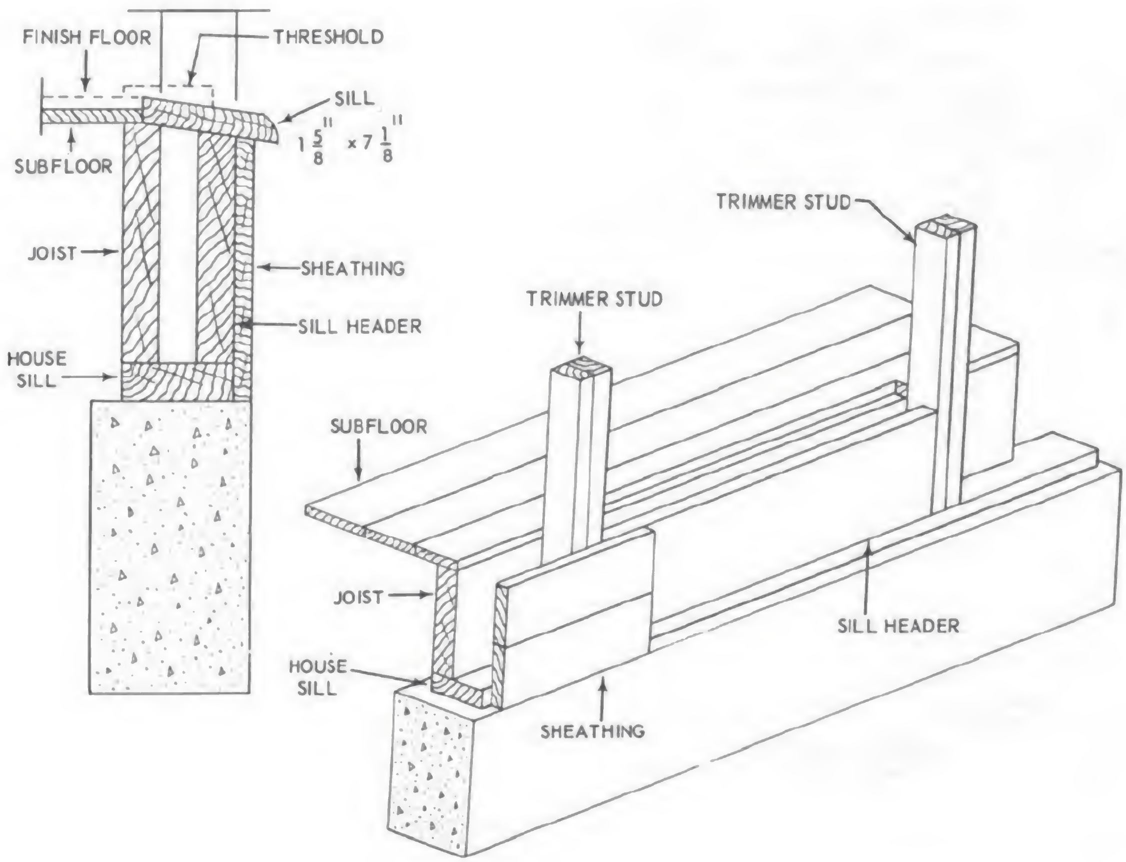

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Figure 4-3.—Outside-door sill installation, balloon framing.

Construction information for a double-hung window finish frame is given in details like those shown in figures 4-4 and 4-5. As with a door frame layout, the starting point for window frame layout is the dimensions of the window as given in the window schedule. The ends of the sill usually fit into dadoes cut in the side jambs, and the length of the sill is equal to the width of the window plus the combined depths of the dadoes.

The overall length of a side jamb equals the height of the window plus the following:

1. The sill bevel allowance (shown in fig. 4-5).
2. The thickness of the sill.
3. The thickness of the head jamb.
4. The height of the side jamb lugs.

The overall length of the head jamb equals the width of the window plus the combined depths of the head jamb dadoes in the side jambs. When the jambs have been cut to correct length, cut the sill and head dadoes in the side jambs.

Next groove the side jamb and the head jambs for the PARTING STOP. In the type of frame shown in figure 4-4, in which the BLIND STOP is nailed to the outer edges of the faces of the jambs, the parting stop is set back from the faces of the jambs a distance equal to the thickness of the window sash plus a clearance allowance of about 1/16 in. In other types of frames the blind stop consists of wood strips nailed to the inner faces of the jambs, and the outer edges of the jambs come flush with the face of the sheathing. In one of these frames the parting strip is set back from the outer edges of the jambs a distance equal to the thickness of the sash, plus the width of the blind stop, plus the amount (if any) that the blind stop is set back from the outer edges of the jambs, plus the same clearance allowance of about 1/16 inch.

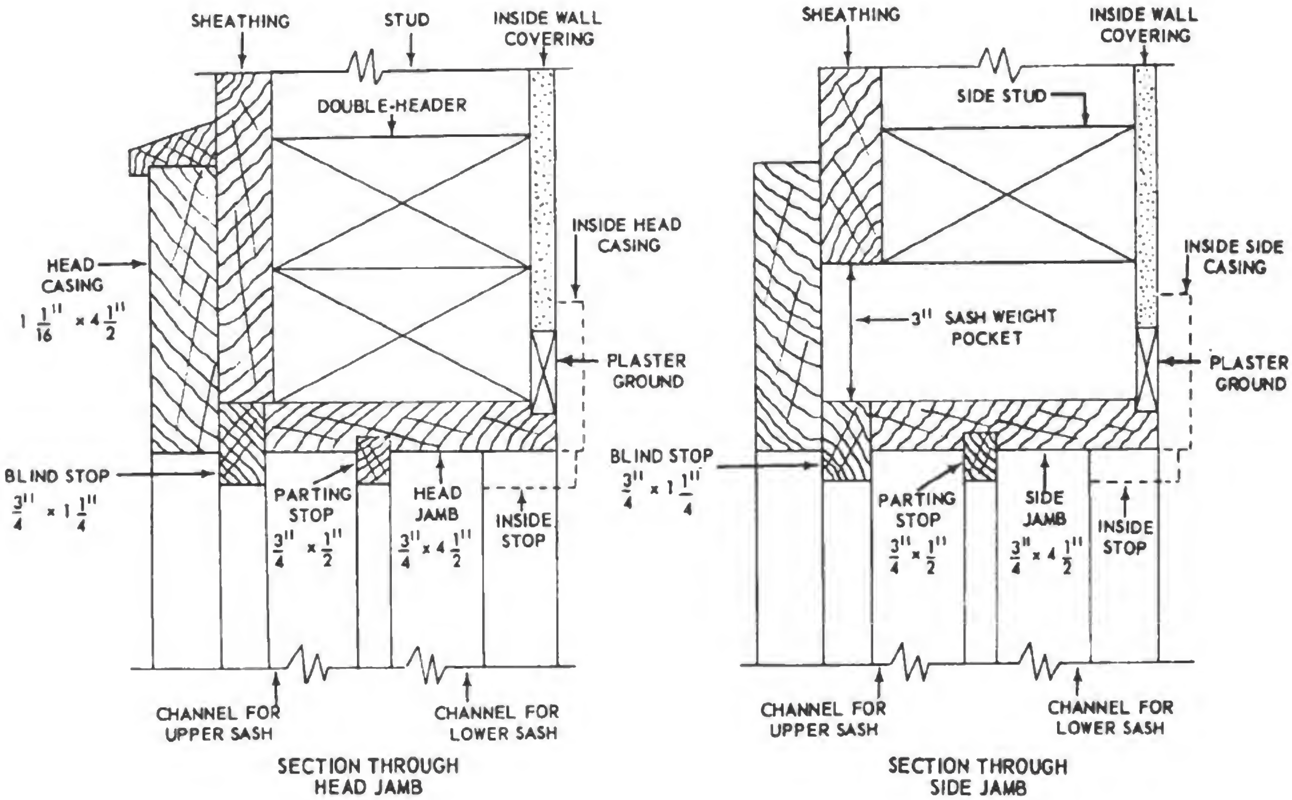

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Figure 4-4.—Double-hung wind w finish frame jamb details.

The best way to lay out the blind stop is to assemble the side jambs and the sill and then measure the lengths of the blind stop sections on the side and head jambs. Nail the blind stop to the jambs; then lay out, cut, and attach the outside casings as for a door. The parting strip doesn't go on until you are ready to install the sash.

SETTING A WINDOW FRAME

Instead of using weights and pulleys with double-hung windows, sash balances are commonly used as counterweights. Basically, sash balances such as spiral, spirex, spira-lift, and clock spring are installed and adjusted in a similar manner. Follow these five basic steps when installing a spiral balance:

(1) With the sash on the frame, put the balance into place, with the spring end down. (The balance may be placed in the groove before the sash is set in the frame.)

(2) Fasten the tube to the center of the sash run with large flathead screws. The top of the balance must be against the header.

(3) The balance must have the attaching arm connected just below the spring.

(4) The sash is fixed to the attaching arm with screws. (Whenever the sash is lowered, the locking piece is automatically released.)

(5) To adjust tension, simply insert a screwdriver blade in the slots at the top of the balance and turn right to increase tension, and left to decrease tension.

INSIDE DOOR FRAMES

An inside door frame consists, technically speaking, only of the jambs; the casings are considered part of the inside wall covering. Inside door jambs are usually made of about 7/8 in. stock, about 1/16 in. wider than the wall thickness between finish surfaces.

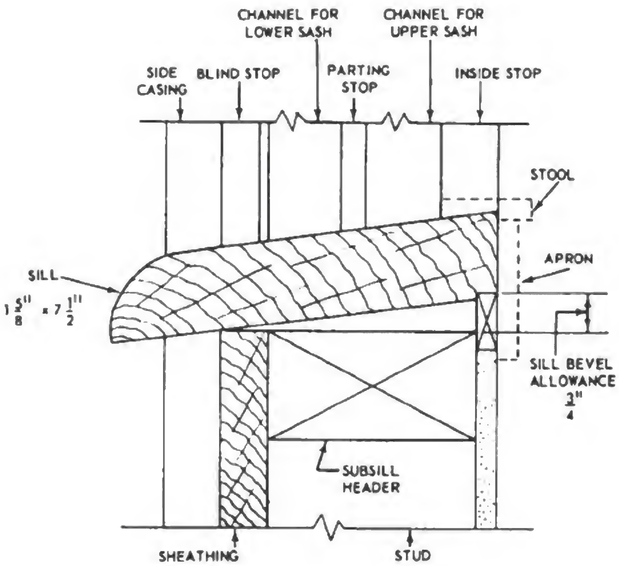

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Figure 4-5.—Double-hung window finish frame sill details.

The overall length of a side jamb equals the vertical distance from the top of the finish floor to the bottom of the rough frame header. On a door without a threshold the distance from the bottom of a side jamb to the bottom of the head jamb dado equals the height of the door (as given on the door schedule), plus 1/2 in. for clearance between the bottom of the door and the top of the finish floor. The overall length of the head jamb equals the prescribed width of the door, plus twice the depth of a head jamb dado. The usual depth for a head jamb dado is 5/16 inch.

The jambs are cut, dadoed, and assembled as previously described for an entrance door—including careful squaring and bracing. An assembled frame is set in place as follows:

Place the frame in the opening, with the bottoms of the side jambs resting on the finish floor. Then check the head jamb for levelness. If it is not level, wedge up the side jamb on the low side until it comes level. Measure the vertical distance between the bottom of the raised side jamb and the finish floor, and cut an equal amount off the bottom of the other side jamb.

If the door has a threshold, cut the threshold to correct length and nail it in place between the bottoms of the side jambs. If the door has no threshold, cut a piece of 1x6 to the width of the finished opening, and set it between the bottoms of the side jambs to serve as a spreader during wedging. An inside door frame is wedged in the rough opening with 10 pairs of shingle-type wedges (5 pairs to each side jamb) as shown in figure 4-6.

Find out from the floor plan which way the door will swing, and mark the hinge jamb (jamb to which the hinges will be attached) on the edge where the hinges will go. Lay off from this edge the thickness of the door, plus 1/2 the width of the door stop, as shown in figure 4-6. Gage a pencil line down the face of the jamb at this point, and a corresponding line on the face of the opposite jamb. Nails driven in the jambs should be staggered 1/2 in. on either side of this line, so they will be concealed by the stop.

Set pairs of shingle wedges behind the side jambs at top and bottom, and proceed to drive the wedges alternately to center the frame and plumb the jambs as previously described for an outside door. Plumb the hinge jamb first, and fasten it with an 8-penny casing nail at the top and another at the bottom, driven through the face of the jamb and the wedges into the trimmer stud. Then repeat the same process on the other jamb (called the LOCK jamb).

Complete the wedging by driving 3 more pairs of wedges behind each of the side jambs.

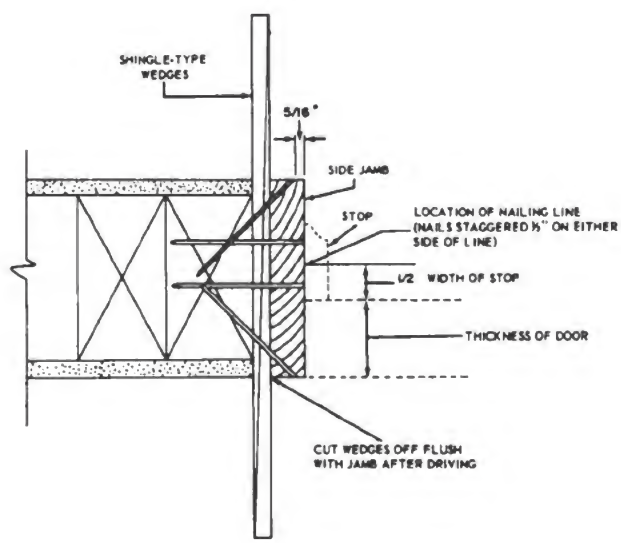

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Figure 4-6.—Wedging and fastening door frame.

On the hinge jamb, place one pair of wedges midway between the top and the bottom of the jamb, and the other two pairs at the hinge locations. Hinges are customarily located 7 in. down from the top of a door and 11 in. up from the bottom. On the lock jamb place one pair of wedges at the lock level (usually about 3 ft. up from the bottom of the door), and the other pairs midway between the middle and the top and bottom pairs.

When wedges have been driven so as to bring the jamb faces perfectly true, drive two 8-penny nails through the face of the jamb into the trimmer stud at each wedge location, as shown in figure 4-6. Then cut the wedges off flush with the jamb edges, and finish nailing the jambs by toenailing 8-penny casing nails through the jambs and the wedges into the trimmer studs, as also shown in figure 4-6. Set these toenails far enough back from the jamb faces to ensure that they will be concealed by the casings.

Casing an inside door is about the same as casing an outside door or window.

INSIDE WINDOW FRAMES

In hasty construction, millwork window frames are seldom used. The window frames are mere openings left in the walls with the stops all nailed to the studs. The sash may be hinged to the inside or the outside of the wall or constructed so as to slide. The latter type of sash is most common in construction because it requires little time to install. Figure 4-7 shows the section and plan of a window and window frame of the type used in the field. After the outside walls have been finished, a 1 by 3 is nailed on top of the girt at the bottom of the window opening to form a sill. A 1 by 2 is nailed to the bottom of the plate and on the side studs and acts as a top for the window sash. One guide is nailed at the bottom of the opening with the top edge flush with the top of the plate. These guides are 1 by 3's, 8 feet long. Stops are nailed to the bottom girt and plate, between the next two studs, to hold the sash in position when open.

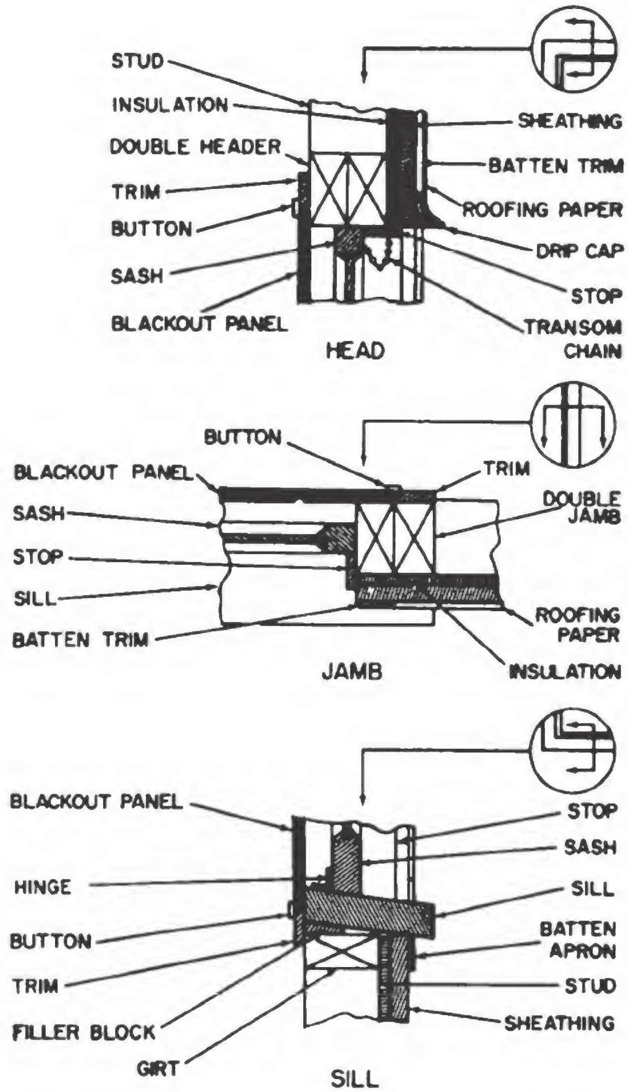

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Figure 4-7.—Detail of wall section with window frame and sash.

WINDOW SASH LAYOUT

The first step in the layout of a window sash is to find out the dimensions of the finished frame opening. If the frame has already been installed, the best thing to do is measure the actual opening. If not, get the dimensions from the window schedule.

Assume that the window is a double-hung window like the one shown in figure 4-8 and that it is listed on the window schedule as MK 3, DH, 2 ft 4 in. x 3 ft 10 in., 12 LTS. This means: Window No. 3, double hung, 2 ft 4 in. wide by 3 ft 10 in. high, 12 lights (panes) of glass. The next step is to examine window No. 3 on an elevation

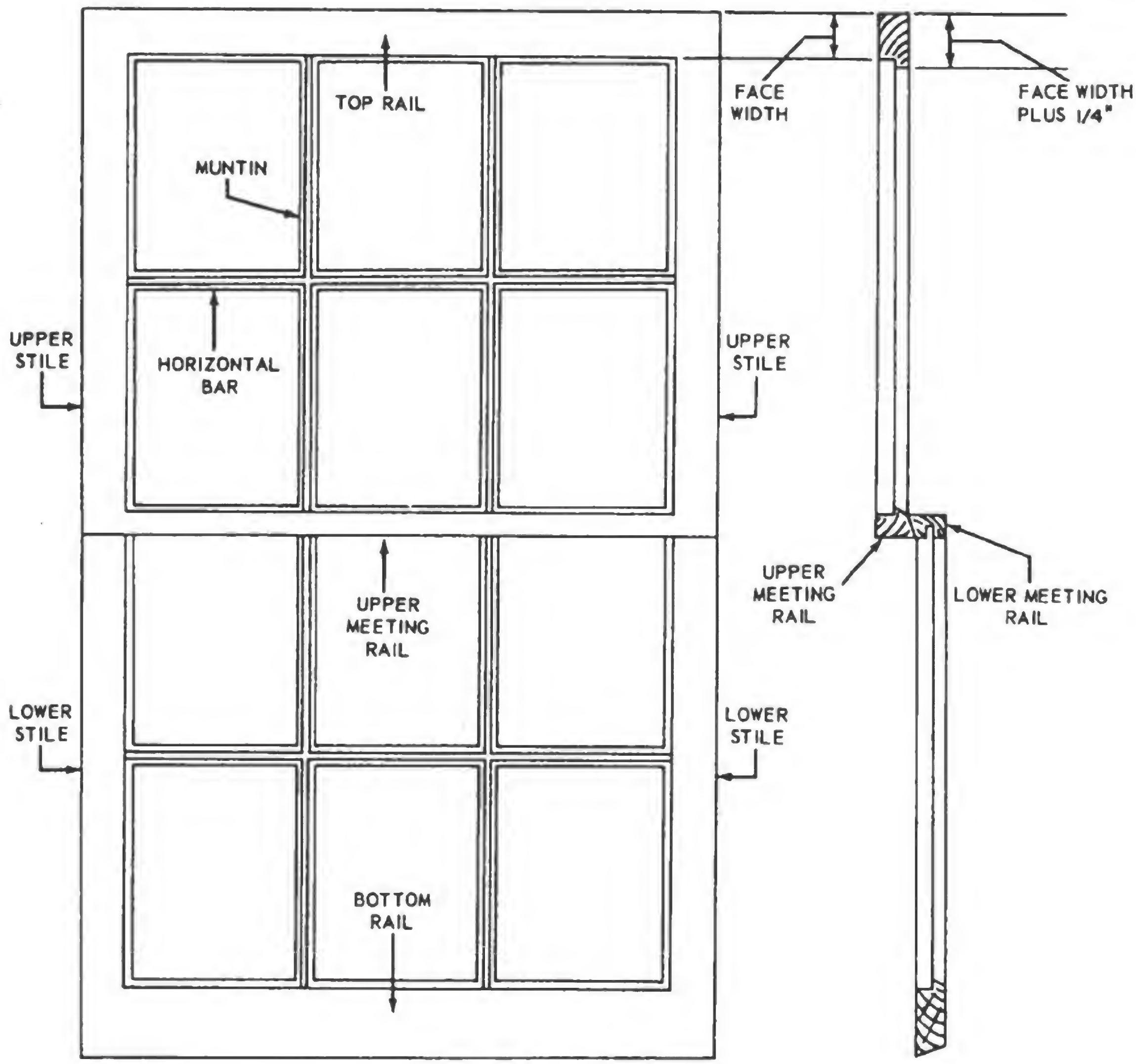

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Figure 4-8.—Double-hung window sash.

in which it appears, to see how the lights of glass are arranged. Assume that you find them arranged as shown in figure 4-8, and that on the upper left-hand light of glass you find the figure 8/10. This figure represents the width (8 in.) and height (10 in.) of each light, ignoring, however, the dimensions of the wooden members (MUNTINS and HORIZONTAL BARS) which separate the lights from each other. Each actual light would be cut to the nominal dimensions, less an allowance for the face dimensions of wooden members.

Your job is to make sash which will be 1/8 in. narrower than the width of the opening and 1/16 in. shorter than the height of the opening. The first step is to determine the FACE WIDTHS (see fig. 4-8) of the stock you will use for rails, stiles, muntins, and horizontal bars. Tables are available in which standard face widths of sash members are given for casement and double-hung windows for all standard sizes of window openings and almost every conceivable arrangement and number of lights of glass. If you do not have access to such a table, or if the avail-

able table does not show your particular size of window opening, the following face widths are standard for stiles and rails:

Top rail: 2 inches
Stile: 2 inches
Meeting rail: 1 inch
Bottom rail: 3 inches

As you can see in figure 4-8, the overall width of a stile or rail (except the lower meeting rail) is the sum of the face width plus the width of the rabbet, which is called a FILLISTER on a window. The standard width for a fillister is 1/4 inch. Therefore, the overall width for a stile or rail (except the lower meeting rail) would be the sum of the face width plus 1/4 inch. For the lower meeting rail the face width and overall width are the same.

The following face widths for muntins and horizontal bars are recommended by the National Woodwork Manufacturer's Association:

Casement sash: 3/16 inch
Double-hung sash with only the upper sash divided: 3/16 inch

Double-hung sash in which both upper and lower sash are divided in the same manner, as follows:

One or two muntins, no horizontal bars: 7/16 inch
One horizontal bar, no muntins: 7/16 inch
One muntin, one horizontal bar: 7/16 inch
Any larger number of muntins and horizontal bars: 3/16 inch

As you can see in figure 4-8, the overall width of a muntin or horizontal bar is the sum of the face width plus twice the width of a fillister, which is 2 x 1/4 in., or 1/2 inch. For the window shown in that figure the face width of a muntin or horizontal bar should be 3/16 inch; therefore, the overall width should be 3/16 in. plus 1/2 in., or 11/16 inch.

Rails are usually joined to stiles with the open mortise-and-tenon joint (commonly called a SLIP joint) shown in figure 4-9. If this joint is used, the length of a rail equals the width of the finished opening, less the clearance allowance of 1/8 inch. The length of the tenon on a rail equals the face width of the stile.

The lower edge of the upper meeting rail should lie midway between the top and bottom of the finished opening when the window is closed.

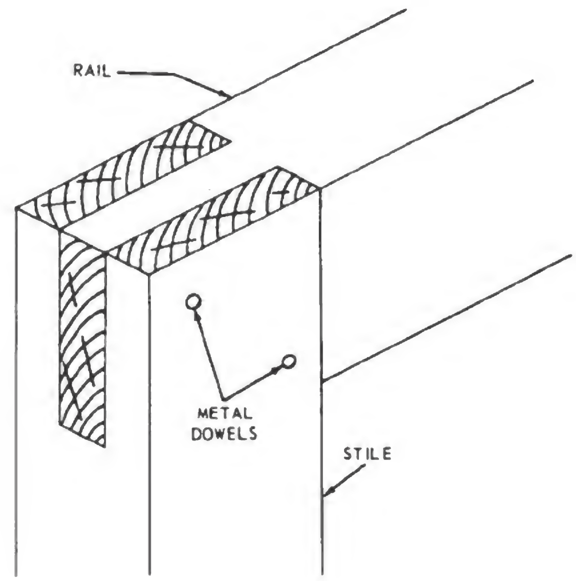

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Figure 4-9.—Slip joint for joining sash rails to stiles.

The length of the upper stile, then, should equal one-half the height of the finished opening, less one-half of the vertical clearance allowance. The lower meeting rail must exactly overlap the upper one, as shown in the right-hand view of figure 4-8. Therefore, the length of a lower stile should equal one-half the height of the finished opening, plus the face width of a meeting rail, minus one-half the vertical clearance allowance.

WINDOW SASH CONSTRUCTION

Lay out, rabbet, mortise-and-tenon, and assemble the rails and stiles first. Then determine the required lengths for muntins by measurements taken on the assembled stiles and rails. Ends of muntins are coped or otherwise shaped to join the edges of rails, which are usually molded or beveled. Muntins are fastened to rails by gluing and/or toenailing with small brads. After muntins have been installed, make measurements in place for segments of bars.

INSTALLING WINDOW SASH

Casement sash is hung about the same way a door is hung.

Double-hung sash consists of an upper and a lower sash, each of which slides vertically in a separate vertical runway. The upper sash slides in the outer runway, the lower sash in the inner runway. Figure 4-10 shows how these runways are formed. The inner side of the outer runway is formed by the parting stop, the outer side by the blind stop (on other types of frames by a side stop). The outer side of the inner runway is formed by the parting stop, the inner side by a side stop nailed to the side jambs.

In most modern double-hung windows the weight of the sash is counterbalanced by a spring device. On one type of device the spring lies inside the jamb, and you simply attach a wire strap to the sash. On another type, however, the spring is set in a groove in the stile.

Steps in fitting and hanging double-hung sash are about as follows:

1. Try the upper sash in the frame for a fit; if necessary, plane down the stiles to get a clearance of 1/8 inch.
2. Notch the ends of the lower sash meeting rail for the parting stop as shown in figure 4-11.
3. Remove the parting stop from the jambs, set the upper sash in its runway, and replace the parting stop. Run the upper sash all the way up and tack it there.
4. Try the lower sash for a side fit, planing down stiles as required to get 1/8 inch clearance.
5. Set the angle of the sill on the sliding T-bevel by lining the handle up with the parting stop and the blade with the sill. Lay off this angle on the bottom of the bottom rail, and plane to the angle.
6. Set the lower sash in its runway, all the way down, and measure the amount by which the tops of the meeting rails are out of flush. Plane this amount off the bottom of the bottom

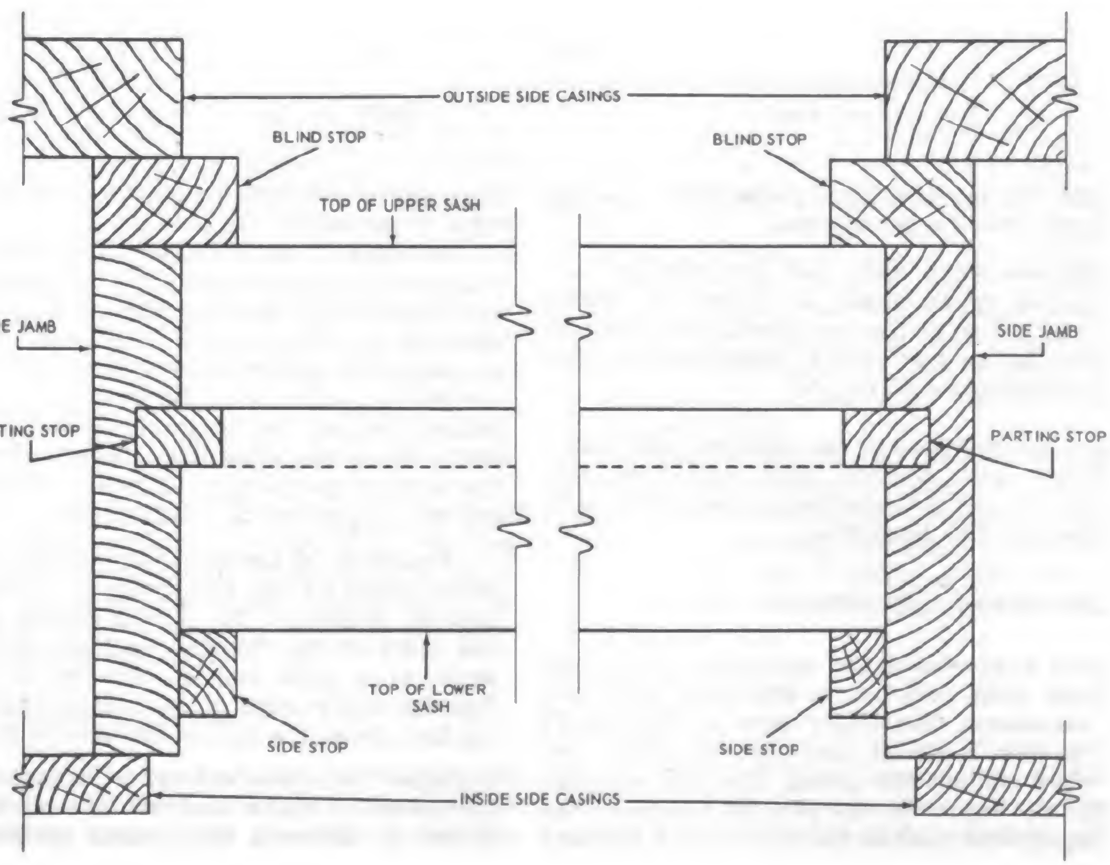

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Figure 4-10.—Section through double-hung frame and sash.

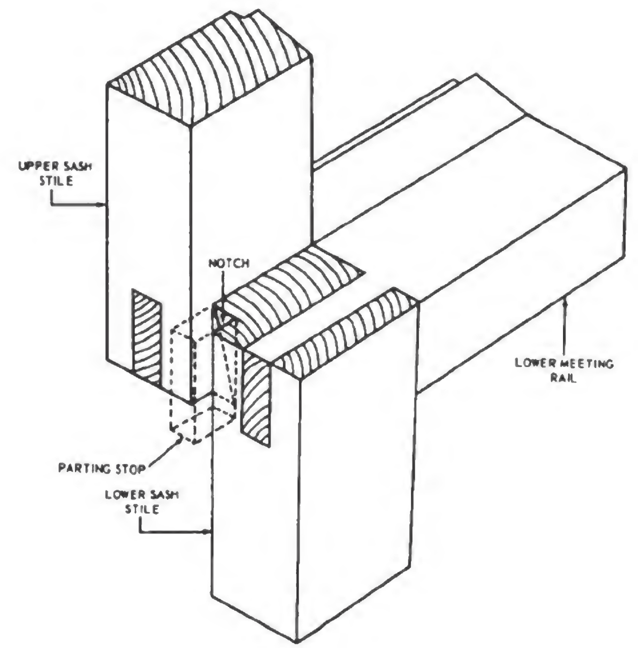

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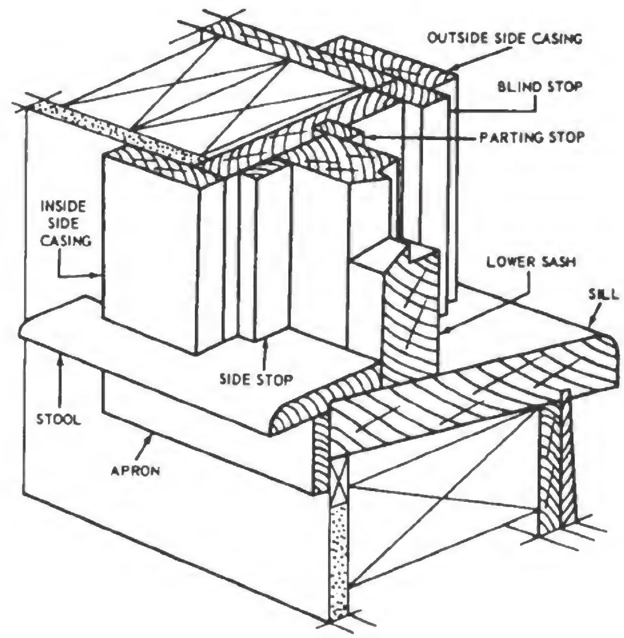
Figure 4-11.—Notching lower sash meeting rail for parting stop.



117.64
Figure 4-12.—Window stool and apron.

rail, until the meeting rails come flush when the lower sash is in closed position.

7. Remove both sash and the parting stop. Replace the upper sash, attaching the spring device according to the manufacturer's instructions. Set the parting stop in place and nail with 8-penny finish nails 12 in. O.C.

The side stop cannot be attached until after the STOOL and APRON have been installed. There is no point in setting in the lower sash until after this has been done.

WINDOW STOOL AND APRON

Figure 4-12 shows the positions of the stool and apron with relation to the other sash and frame members. The upper view of figure 4-13 shows a plan view of the stool in place; the lower view shows the stool. You can see that distance A, which is the overall length of the stool, equals the sum of the width of the finished opening, plus twice the amount that the inner edge of each side casing is to be set back from the face of the side jamb, plus twice the width of a side casing, plus twice the amount that each end of the stool is to extend beyond the outer edge of the side casing.

Distance C equals the horizontal distance, measured along the face of the side jamb, between the inner edge of the side jamb and the inner face of the lower sash. An allowance of 1/16 in. should be deducted for clearance.

Distance C is also the width of the triangular rabbet in the bottom of the stool. Lay off this width from the edge, then take off the angle of the sill on the sliding T-bevel and use it to lay off the angle on the end section of the stool.

The ends of the apron should line up with the outer edges of the side casings. Therefore, the overall length of the apron equals the sum of the width of the finished opening, plus twice the width of a side casing, plus twice the amount that the inner edge of each side casing is to be set back from the face of the side jamb.

When the stool and apron have been cut, set the stool in place and set the apron in place under it. Place a try square on the stool and adjust the vertical position of the apron to bring the top of the stool at a right angle to the face of the parting stop. Then nail the apron in position with 8-penny finish nails, 12 in. O.C.

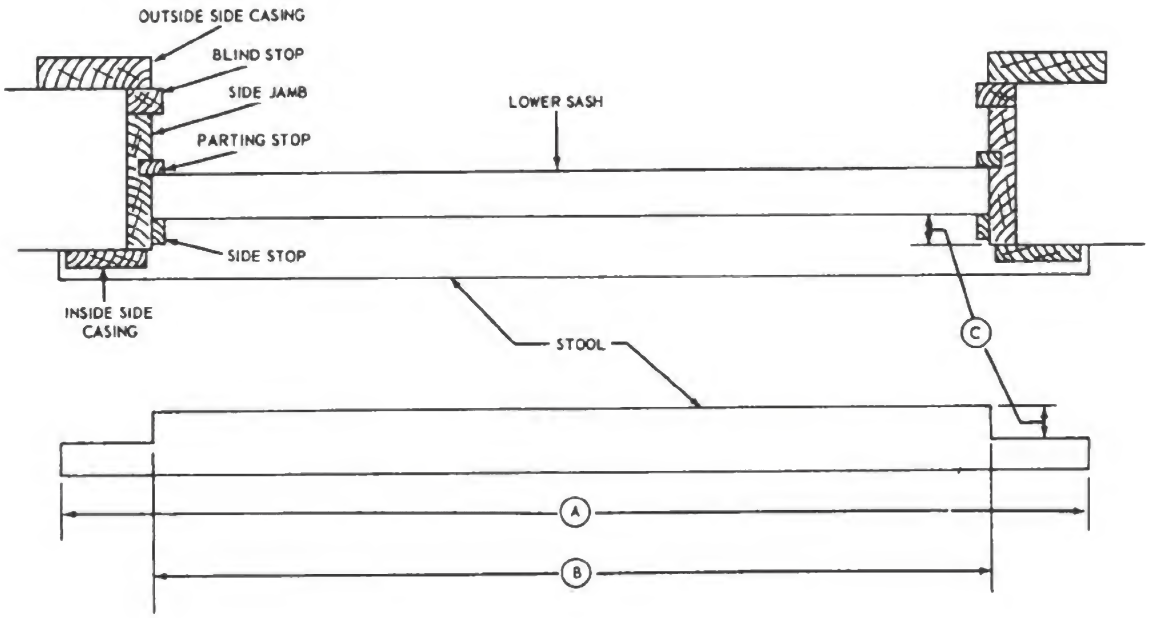


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Figure 4-13.—Window stool layout.

You nail the stool down to the apron. Before doing this, select a board long enough to serve as a shore between the lower edge of the apron and the subfloor, to back the apron against the nail-driving. Nail the stool down with 8-penny finish nails 12 in. O.C.

With the stool and apron in position, you can install the lower sash, attaching the spring device as required. You can then measure in place and install the side stop. The extension of the side stop across the head jamb, called the HEAD STOP, is installed first. Its length equals the width of the finished opening. Cut it to correct length, raise the lower sash all the way, set the head stop 1/16 in. away from the face of the meeting rail, and nail on with 4-penny finish nails 12 in. O.C. The length of a side stop then equals the measured distance from the face of the head stop to the top of the stool.

WINDOW INSIDE CASINGS

The length of a head casing equals the width of the finished opening, plus twice the width of a side casing, plus twice the amount that the inner edge of each side casing is to be set back from the face of the side jamb. The length of a side casing depends on the manner in which the side casings and head casing are joined at the corners. For SQUARE-CUT TRIM, in which the top of a side casing square-butts against the lower edge of the head casing, the length of a side casing equals the vertical distance between the top of the stool and the lower edge of the head casing. For MITER-CUT TRIM (in which the side casings are miter-joined to the head casing), the length of a side casing is the same as the vertical distance between the top of the stool and the upper edge of the head casing.

Cut the casings to correct lengths, and miter the ends if the trim is miter-cut. Nail the side casings on first. Drive 4-penny finish nails 12 in. O.C. through the casing into the edge of the jamb, and 8-penny finish nails 12 in. O.C. through the casing and wall covering into the trimmer stud.

METAL WINDOWS

Either aluminum or steel windows will most likely be installed in a permanent type of building. Information on construction requirements and pointers on installing metal windows are given below.

Regardless of the type of window used, it should be of the size, combination, and type indicated or specified. Windows should be con-

structed to produce the results specified and to assure a neat appearance. Permanent joints should be formed by welding or by mechanical fastenings, as specified for each type window. Joints should be of sufficient strength to maintain the structural value of members connected. Welded joints should be solid, have excess metal removed, and be dressed smooth on exposed and contact surfaces. The dressing should be done so that no discoloration or roughness will show after finishing. Joints formed with mechanical fastenings should be closely fitted and made permanently watertight. Frames and sash, including ventilators, come assembled as a unit with hardware unattached.

Hardware should be of suitable design and should have sufficient strength to perform the function for which it is used. It should be attached securely to the windows with non-corrosive bolts or machine screws; sheet metal screws should not be used. Where fixed screens are specified, the hardware should be especially adapted to permit satisfactory operation of ventilators.

As a supervisor, make sure your men exercise care in handling windows to avoid dropping them. In addition, see that windows are stored upright on pieces of lumber to keep them off the ground, and are covered thoroughly to protect them from the elements.

Windows should be installed and adjusted by experienced and qualified Builders. Aluminum windows in concrete or masonry walls should be set in prepared openings. Unless indicated or specified otherwise, all other windows should be built-in as the work progresses, or they should be installed without forcing into prepared openings. Windows should be set at the proper elevation, location, and reveal. They should be set plumb, square, level, and in alignment. They should also be braced, strutted, and stayed properly to prevent distortion and misalignment. Ventilators and operating parts should be protected against accumulation of cement, lime, and other building materials, by keeping ventilators tightly closed and wired fast to the frame. Screws or bolts in sill members, joints at mullions, and contacts of windows with sills, built-in fins, or subframes should be bedded in mastic sealant of a type recommended by the window manufacturer. Windows should be installed in a manner that will prevent entrance of water.

Ample provision should be made for securing units to each other, to masonry, or to other adjoining or adjacent construction. Windows that are to be installed in direct contact with masonry must have head and jamb members designed to enter into masonry not less than 7/16 inch. Where windows are set in prepared masonry openings, the necessary anchorage or fins should be placed during progress of wall construction. Anchors and fastenings should be built into, anchored, or bolted to the jambs of openings, and should be fastened securely to the windows or frames and to the adjoining construction. Unless indicated otherwise, anchors should be spaced not more than 18 inches apart on jambs and sills. Anchors and fastenings should have sufficient strength to hold the member firmly in position.

After windows have been installed and upon completion of glazing and painting, all ventilators and hardware should be adjusted to operate smoothly and to be weathertight when ventilators are closed and locked. Hardware and parts should be lubricated as necessary. Adjustments and tests should be as follows:

(a) Double-hung windows should have balances adjusted to proper tension, and guides waxed or lubricated.

(b) Casements equipped with rotary operators should be adjusted so that the top of the ventilator makes contact with the frame approximately 1/4 inch in advance of the bottom.

(c) Casements equipped with friction hinges, or friction holders, should be adjusted to proper tension.

(d) Projected sash should have arms or slides lubricated and adjusted to proper tension.

(e) Awning windows should have arms to ventilators adjusted so that the bottom edge of each ventilator makes continuous initial contact with frames when closed.

(f) Where windows are weatherstripped, the weatherstripping should make weathertight contact with frames when ventilators are closed and locked. The weatherstripping should not cause binding of sash, or prevent closing and locking of the ventilator.

After adjustment, all non-weatherstripped steel and aluminum windows, except security and commercial projected steel windows, should comply with prescribed feeler gage tests. Windows failing to comply with the tests should be removed and replaced with new windows, or shall be corrected and restored to approved condition meeting the required tests. When ventilators are closed and locked, the metal-to-metal contacts between ventilators and their

frames should conform to the following requirements:

Whenever conducting the feeler gage test on SIDE-HUNG VENTILATORS, the Builder should remember that it should not be possible to freely insert a steel feeler gage, 2 inches wide by 0.031 inch thick, at any point between the outside contacts of ventilator and frame; nor to freely insert a similar feeler gage, 0.020 inch thick, between more than 40 percent of such contacts.

Remember that for PROJECTED-OUT HORIZONTAL VENTILATORS, it should not be possible to freely insert a steel feeler gage, 2 inches wide by 0.031 inch thick, between the top rail inside contacts, or between the bottom and side rail outside contacts; nor to freely insert a similar feeler gage, 0.020 inch thick, between more than 40 percent of such contacts.

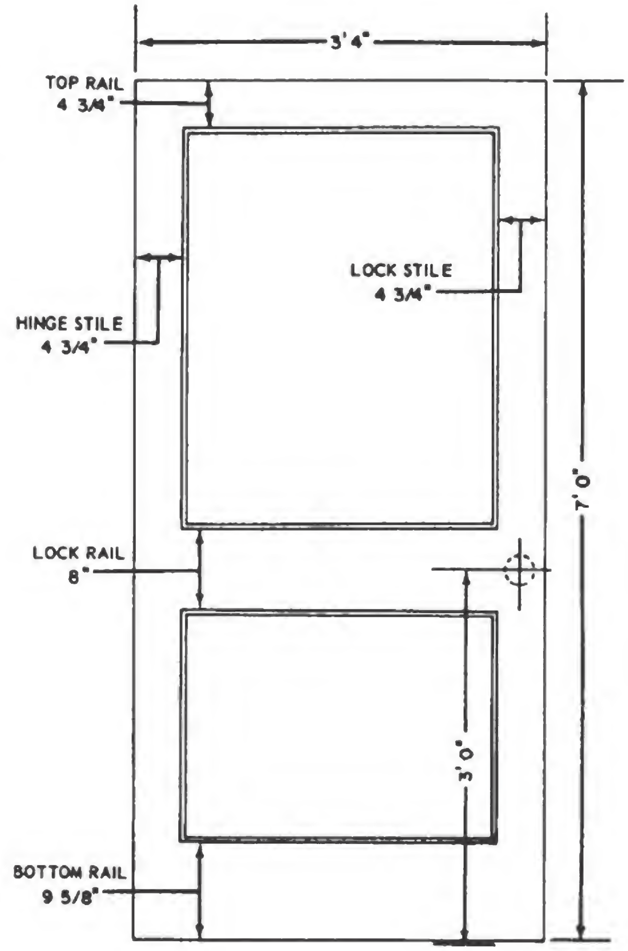
For PROJECTED-IN HORIZONTAL VENTILATORS, it should not be possible to freely insert a steel feeler gage, 2 inches wide by 0.031 inch thick, between the bottom rail outside contacts, or between the top and side rail inside contacts; nor to freely insert a similar feeler gage, 0.020 inch thick, between more than 40 percent of such contacts.

DOORS

Ponderosa pine and Douglas fir are the woods most frequently used for doors. Stock for outside-door stiles and rails is usually about 1-3/4 in. thick; for inside-door stiles and rails about 1-3/8 in. thick. Widths of rails and stiles given on drawings are FACE widths, that is, widths exclusive of any rabbet the member might have.

PARTS OF A DOOR

Doors are made in many styles, but most of the doors you deal with may be simple PANEL doors of the type shown in figure 4-14. A door of this type contains one or more PANELS, enclosed in a FRAME consisting of vertical members called STILES and horizontal members called RAILS. Any intermediate vertical frame members between the stiles are called MUNTINS. Any intermediate horizontal frame members between the top and bottom rails, other than the lock rail, are called INTERMEDIATE RAILS.

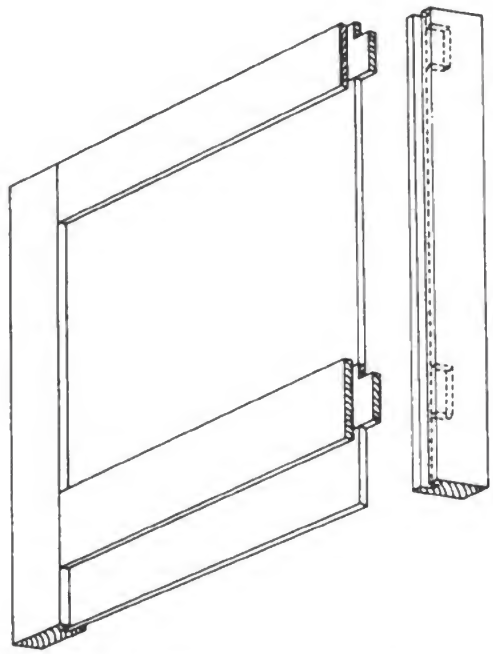


45.511
Figure 4-14.—Parts of a panel door.

Figure 4-15 shows the customary method of joining a panel door. Here the inner edges of the rails and stiles are grooved to receive the panels. However, these edges might be rabbeted, and the panel held in by strips of molding. As you can see, the rails are joined to the stiles with haunched mortise-and-tenon joints.

FITTING A DOOR

If a number of doors are to be fitted and hung, a DOOR JACK like the one shown in figure 4-16 should be made, to hold doors for the planing of edges and the installation of HARDWARE (hinges, locks, knobs, and other metal fittings).



117.67
Figure 4-15.—Method of joining a panel door.

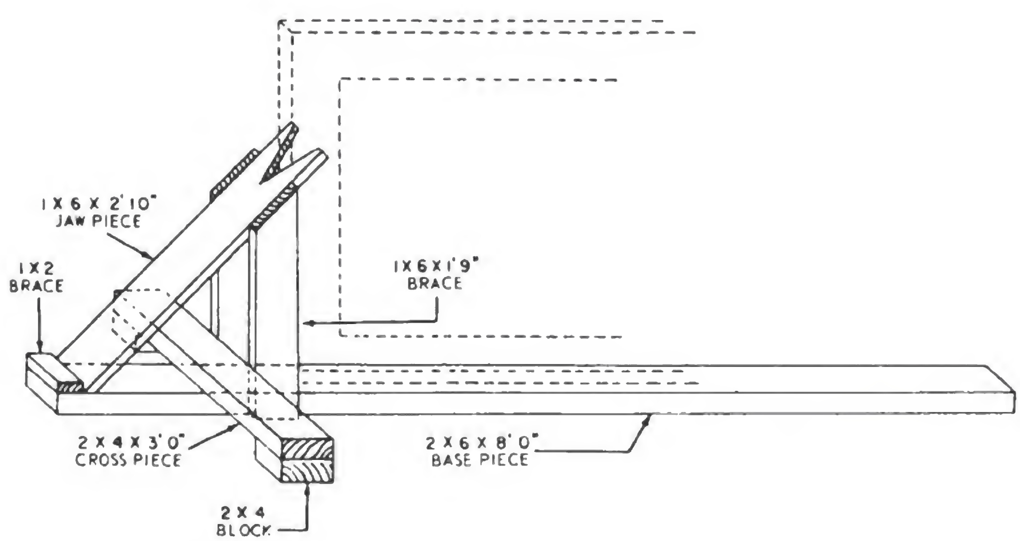
The first step in fitting a door is to determine from the floor plan which stile is the hinge stile and which the lock stile, and to mark the stiles and the corresponding jambs accordingly. Next, carefully measure the height of the finished opening ALONG BOTH SIDE JAMBS and the width AT BOTH TOP AND BOTTOM. The finished opening should be rectangular, but IT MIGHT NOT BE, and your job now is to fit the door to the opening regardless of the shape of the opening.

A well-fitted door, when hung, should conform to the shape of the finished opening with a clearance of 1/16 in. at sides and top. For an inside door without sill or threshold there should be a bottom clearance above the finish floor of from 3/8 to 1/2 inch. This is required to ensure that the door will swing clear of carpeting. For extra-thick carpeting the clearance would have to be greater than 1/2 inch. For a door with a sill and no threshold, or with a threshold, the bottom clearance should be 1/16 in. above the sill or threshold.

Lay off the measured dimensions of the opening, less clearance allowances, on the door. Check the jambs for trueness, and if you find any irregularities, transfer them to the corresponding stiles. Then place the door in the jack and plane to the lines, checking for fit repeatedly, as you near the line dimension on the second stile you plane, by setting the door in the opening.

HANGING A DOOR

Most of the doors you deal with will be equipped with SIDE hinges—meaning, hinges

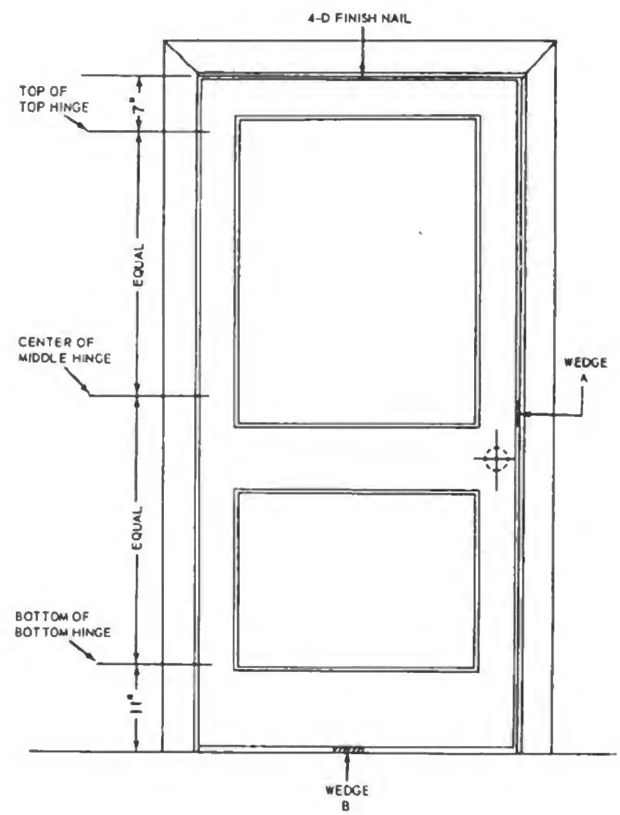


117.68
Figure 4-16.—Door jack.

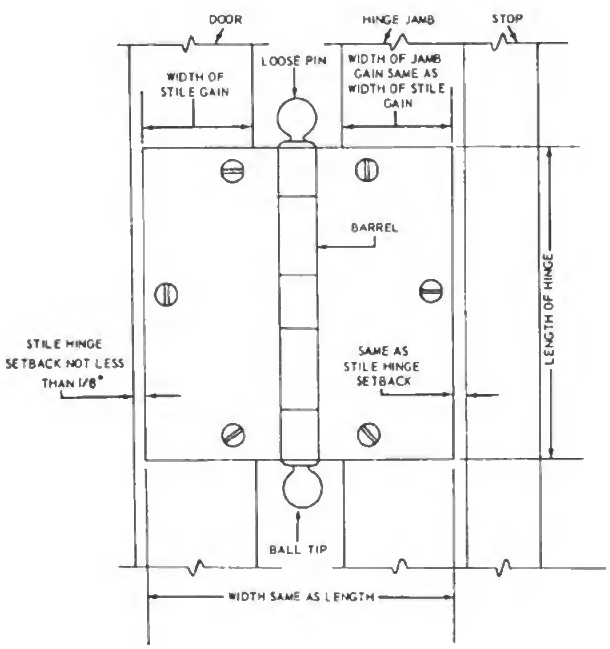
attached to one stile or the other. The most common type of side hinge is the LOOSE-PIN BUTT MORTISE hinge (see fig. 4-17). A hinge of this type consists of two rectangular leaves, pivoted on a pin which is called a loose pin because it can be removed by simple extraction. The hinge is called a mortise hinge because the leaves are mortised into gains cut in the hinge stile of the door and the hinge jamb of the frame.

The first step in hanging a door is to lay out the locations of the hinges on the hinge stile and the hinge jamb. Set the door in the frame, and set a wedge lightly between the lock stile and the lock jamb, to bring the hinge stile against the hinge jamb, as shown in figure 4-18 (wedge A). Then place a 4-penny finish nail (which has a diameter of about 1/16 in.) between the top rail and the head jamb, and wedge the door upward (wedge B) until the nail just contacts both the head jamb and the top rail.

Outside doors usually have 3 hinges; inside doors as a rule only two. The distance from the top of the door to the top of the top hinge, and from the surface of the finish floor to the bottom of the bottom hinge, may be specified. If not, the distances customarily used are 7 and 11



117.70
Figure 4-18. — Laying out hinge locations on hinge stile and hinge jamb.



117.69
Figure 4-17. — Loose-pin butt mortise hinge.

inches, as shown in figure 4-18. The middle hinge, if there is one, is located midway between the other two.

The size of a loose-pin butt mortise hinge is designated by the length (longer dimension) of the leaf in inches. Sizes for doors of various frame thicknesses in inches and widths in inches are as follows:

Frame Thickness of Door	Width of Door	Size of Hinge
1-1/8 to 1-3/8	up to 32	3-1/2
1-1/8 to 1-3/8	32+ to 37	4
1-3/8+ to 1-7/8	up to 32	4-1/2
1-3/8+ to 1-7/8	32+ to 37	5
1-3/8+ to 1-7/8	37+ to 43	5 extra heavy
1-7/8+	up to 43	5 extra heavy
1-7/8+	43+	6 extra heavy

Place the door in the door jack and lay off the outlines of the gains at the marks on the hinge stile, using a leaf as a marker. The STILE HINGE SETBACK shown in figure 4-17 should be not less than 1/8 in., and is usually made about 1/4 inch. Lay out gains of exactly the same size at the marks on the hinge jamb. Then chisel out the gains to a depth exactly equal to the thickness of a leaf.

Separate the leaves on the hinges by extracting the loose pins, and screw the leaves into the gains, taking care to ensure that the loose pin will be up when the door is hung in place. Hang the door in place, insert the loose pins, and check the clearances at the side jambs. If the clearance along the hinge jamb is too large and that along the lock jamb too small, the gains are not deep enough. If the clearance along the hinge jamb is too small and that along the lock jamb too large, the gains are too deep. You can correct the first situation by cutting the gains deeper, the second by shimming up the leaves by placing strips of cardboard in the gains.

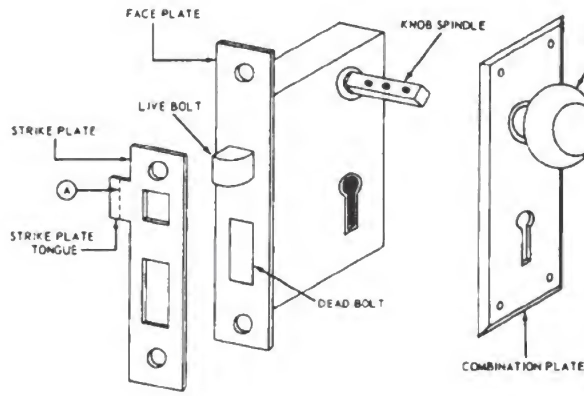
INSTALLING LOCKS

After placing hinges in position, mark off the position of the lock on the lock stile. The lock is placed about 36 inches from the floor level. Two major types of lock are the mortise-type and the cylinder-type lock.

Mortise-Type Lock

A mortise-type lock is one which fits into a mortise cut in the lock stile. (See fig. 4-19.) The procedure for installing a mortise-type lock is as follows:

1. Open the door to a convenient working position, and check it in place with wedges under the bottom near the outer edge.
2. Measure up 36 inches from the floor (the usual knob height) and square a line across the face of the lock stile.
3. Place the lock against the face of the lock stile, with the face plate flush with the edge of the stile and the knob spindle hole even with the drawn line on the stile, and mark the location of the spindle hole center on the line. Also mark the location of the keyhole.
4. With the lock still in the same position, line the locations of the top and bottom of the lock on the face of the stile. Remove the lock

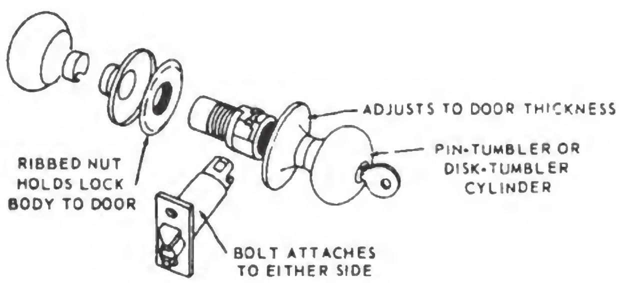


117.71

Figure 4-19.— Parts of a mortise lock.

and square these lines across the edge of the stile.

5. Run a vertical centerline between the lock lines on the stile edge. Lay off one-half the thickness of the lock on either side of this centerline, and run vertical lines at these points. You now have a rectangular outline on the edge of the stile of the same dimensions as the section dimensions of the lock.
6. Bore 3/4 in. diameter holes through the stile at the knob spindle and keyhole marks.
7. Cut the mortise for the lock from the edge of the stile. Rough it out first by a series of holes bored with an auger bit 1/16 in. larger than the thickness of the lock. Finish cutting the mortise out with a mortising chisel.
8. Set the lock in the mortise, press the face plate tightly against the edge of the stile, and outline the face plate on the edge with a scratch awl. This is the outline of the gain for the face plate.
9. Chisel out the gain, in depth equal to the thickness of the face plate.
10. Insert the lock and fasten it in place with the face plate screws. Attach the combination plates, insert the spindle, and attach the knobs.
11. Turn out the dead bolt with the key, and close the door far enough to bring the live and dead bolts into contact with the edge of the lock jamb. Mark the locations of the bolts on the jamb.
12. Place the strike plate against the face plate, with the bolts properly located in the strike plate openings, and draw a line along the strike plate tongue at the door edge. When the strike plate is in correct position on the



133.161
Figure 4-20.—Parts of a cylinder lock.

lock jamb, the edge of the jamb will lie along this line (line A in fig. 4-19).

13. Place the strike plate in correct position on the lock jamb, with the bolt holes at the bolt hole marks and the edge of the jamb at line A, and score a line around it with the scratch awl. This is the outline of the strike plate gain. Remove the plate and chisel out the gain to the thickness of the plate.

14. Set the strike plate in the gain and attach it to the jamb with the strike plate screws.

15. Bore and chisel out the wood behind the bolt holes, deep enough to allow the bolts to pass through the strike plate to their full extension.

Cylinder-Type Lock

The parts of an ordinary cylinder-type lock for a door are shown in figure 4-20. The procedure for installing a lock of this type is as follows:

1. Open the door to a convenient working position and check it in place with wedges under the bottom near the outer edge.

2. Measure up 36 in. from the floor (the usual knob height), and square a line across the face and edge of the lock stile.

3. Use the template that is usually supplied with a cylinder lock; place the template on the face of the door (at proper height and alignment with layout lines) and mark the center of holes to be drilled. (See fig. 4-21.)

4. Drill the holes through the face of the door. Then drill the one through the edge to receive the latch bolt; it should be slightly deeper than the length of the bolt.

5. Cut a gain for the latch-bolt mounting plate, and install the latch unit.

6. Install exterior and interior knobs.

7. Find the position of the strike plate and install it in the jamb.

SUPERVISION

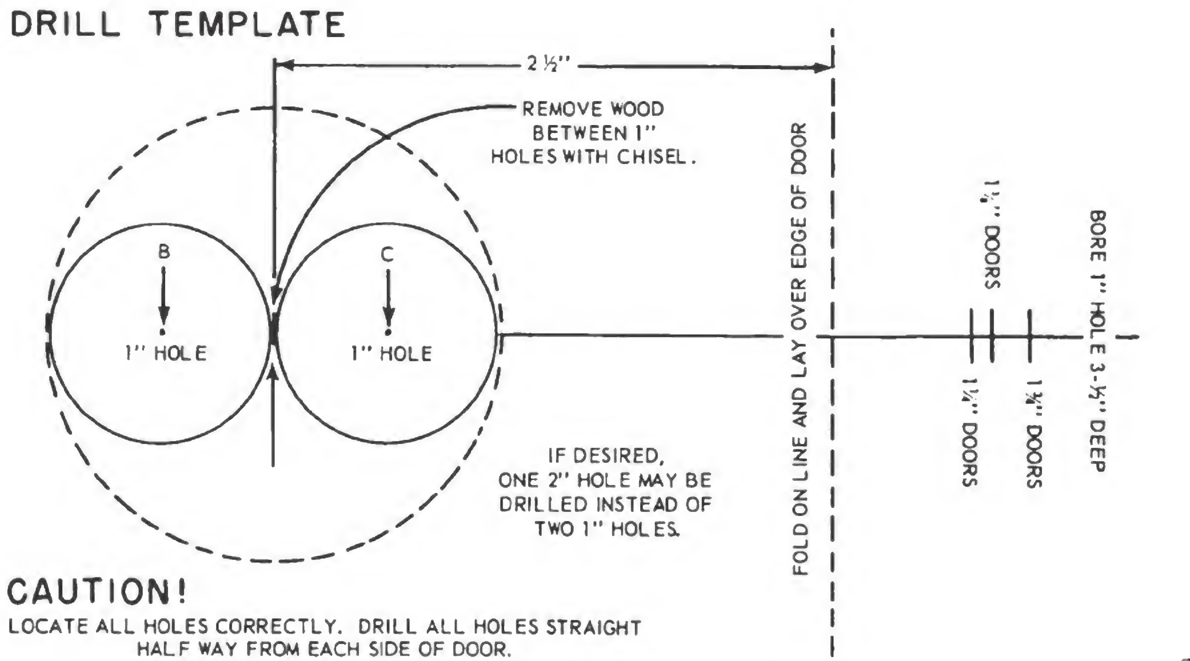
As a Builder 1 or C, you will be responsible for supervising crews engaged in finish carpentry operations, as well as other phases of the Builder rating. You are expected to know and understand the job to be done, as well as know the capabilities of your men. Many pages could be written on supervision, and the subject still not be covered in complete detail. With that in mind, a few hints on supervision are given below. Additional information that will aid you in carrying out your supervisory duties is presented in chapter 9 of this training course.

It is especially important that a supervisor be able to ORGANIZE. This simply means that he should be able to look at the situation and plan the steps that will bring about the desired results. Suppose you have to assign a crew of men to fabricate doors and windows for a new building being constructed. You should look at the job to be done and estimate how many manhours are required to complete it; you will probably have been given a date by which the work is to be completed. Next (or perhaps even before making your estimate of manhours), plan the sequence of operations. Make sure that you also know the answer to the following questions: What is the size of the windows and how many doors and windows are required? Is the material being shipped in, or being prepared at the activity? What equipment is available, and what is its condition?

Before assigning work, give careful consideration to the qualifications of your men. Are they experienced Builders? Will any training be required before certain men can wedge and hang a door properly? Are any men scheduled for leave? Will you need to request additional men? After getting answers to these questions, you should be able to assign men to various jobs.

How well you are able to carry out these steps is directly related to your ability to organize.

In addition to organizing, you must be able to DELEGATE. This is one of the most important



133.162
Figure 4-21.—One type of template.

characteristics of a good supervisor. Failure to delegate is a common failing of a new supervisor. It is natural to want to carry out the details of a job yourself, particularly when you know that you can do it better than any of your subordinates. Trying to do too much, however, is one of the quickest ways to get bogged down in details and to slow down a large operation. On some projects, you may have crews working in several different places. Obviously, you cannot be in two places at the same time. There will be many occasions when a Builder needs assistance or instruction on some problem that arises. If he has to wait until you are available, then valuable time may be lost. It is important, therefore, for you to delegate authority to one or more of your crew members to make decisions in certain matters. You must also remember that, although you delegate authority, you are still responsible for the job.

The ability to COORDINATE operations is another important aspect of good supervision. When a number of operations are in progress, it is important that they be planned so one can follow another without delay. If a glazier is kept waiting because there are not enough frames available, this is evidence of poor coordination; or if a person installing locks has to wait because the door has not been put on the hinges beforehand, this is also evidence of inadequate coordination. From these examples, you can see that supervision requires planning, coordinating, delegating, and organizing. As you can see, they are closely related.

Periodic inspections are an effective means of helping to ensure proper quality of work done under your supervision. Let your men know that their work will be inspected. Make sure that the work you inspect is technically correct, as well as neat. You are aware, of course, that finish carpentry work usually requires a high degree of skill. Since the work is visible, it must be neatly and accurately done so as to give eye appeal, as well as serve its intended purpose. So insist that finish carpentry work be attractive and professional in appearance. When you make an inspection, let the man concerned know how well or how poorly he did the job. A man's work is not likely to improve if he is not told specifically wherein his work needs improvement; and a man who has done an excellent job will be motivated to continue this level of work if you let him know that good work is noted and appreciated.

Safety and production go hand in hand. Every supervisor should consider the safety of his men

as one of his chief responsibilities. Of course the supervisor must practice safety himself—if he expects his men to carefully observe safety precautions. In teaching a new job or operation, always emphasize the safety measures that apply. In planning your jobs, make sure you keep safety in mind. Do not wait until after an accident to teach safety. Remember that a lost-time injury means a nonproducer. And a high accident rate certainly won't reflect favorably upon your ability as a supervisor. To show concern over the safety of your men not only will pay off in production, but also will gain more respect for you from your subordinates.

CHAPTER 5

CONCRETE

Concrete consists of a carefully proportioned mixture of cement, fine aggregates, coarse aggregates, and clean water. The cement serves the purpose of binding the fine and coarse aggregates into a dense mass. When concrete is in a semiliquid state, you may cast, mold, or spray it under pneumatic pressure into any desired shape or size. The setting of concrete is its change from a soft, fluid mixture to a solid mass. Concrete construction, once confined largely to paving and foundations, has been developed to the point where both large and small buildings are not constructed entirely of concrete, with concrete joists (usually called floor beams), concrete studs (usually called columns), concrete walls, concrete floors, and concrete roofs.

In this chapter we will discuss some of the major factors concerning the design of concrete forms. We will point out some of the types of equipment which you are likely to find at concrete batch plants. Information is provided on the control of concrete mixes and batching. A brief discussion also is included on the method of slab form concrete casting. You are aware, of course, that concrete block plays a vital role nowadays in Seabee construction. In that case we will take up various factors concerning the manufacture of concrete block. As part of this instruction, information also is given on principles of cement-plaster and mortar mix design.

FORMWORK

The various types of concrete forms (for footings, walls, columns, beams, girders, floor slabs, pavement slabs, and the like) are explained in Builder 3 & 2. In this discussion we will cover some of the form design considerations which you must understand before you can construct formwork for a given concrete structure.

Formwork may represent as much as one-third of the total cost of a concrete structure, so the importance of the design and construction of this phase of a project cannot be overemphasized. The character of the structure, availability of equipment and form materials, anticipated repeated use of the forms, and familiarity with methods of construction influence design and planning of the formwork. Forms must be designed with a knowledge of the strength of the materials and the loads to be carried. The ultimate shape, dimensions, and surface finish must also be considered in the preliminary planning phase.

Forms for concrete structures must be tight, rigid, and strong. If forms are not tight, there will be a loss of mortar which may result in honeycomb, or a loss of water that causes sand streaking. The forms must be braced enough to stay in alignment, and strong enough to hold the concrete. Special care should be taken in bracing and tying down forms, such as those for retaining walls, in which the mass of concrete is large at the bottom and tapers toward the top. In this type of construction and in other types, such as the first placing for walls and columns, the concrete tends to lift the form above its proper elevation. If the forms are to be used again, they must be easily removed and re-erected without damage. Most forms are made of wood but steel forms are commonly used for work involving large unbroken surfaces, such as retaining walls, tunnels, pavements, curbs, and sidewalks. Steel forms for sidewalks, curbs, and pavements are especially advantageous since they can be used many times.

PRESSURE ON CONCRETE FORMS

Concrete forms must be constructed to resist the pressure exerted on them by the freshly placed concrete without deflection (sidewise displacement) beyond a specified maximum. This maximum is very small; for a wall form, for

example, the maximum deflection of sheathing, studs, and wales is not over 1/270th of the span.

Fresh, fluid concrete exerts a very considerable lateral (sidewise) pressure on the form sheathing. The pressure at the bottom of a fresh-placed layer is greater than that at the top, and increases of course with the height of the layer. Therefore, the greater the VERTICAL RATE OF PLACEMENT is (that is, the higher you make a fresh-placed layer), the greater will be the pressure exerted. Also, for a layer of given depth, the pressure increases at lower temperatures as the concrete will set at a slower rate. As the concrete begins to set, however, (initial set starts about an hour after the water has been added to the dry mix), the pressure decreases to the point where it becomes zero after about 24 hours.

You design formwork for a given pressure by determining the maximum spacing of studs and wales of given dimensions, used with sheathing of given thickness, required to resist that pressure. The first problem, then, is to determine the pressure that must be resisted, and the first problem here is to determine the vertical rate of placement.

VERTICAL RATE OF PLACEMENT

To determine the vertical rate of placement, you divide the quantity of concrete which is placed into the form in an hour (in cu ft) by the horizontal area of the form space being filled. Suppose you are filling a wall section for a wall 30 ft long by 1 ft thick. Then the horizontal area is 30 sq ft.

The ordinary 16-cu ft mixer has an hourly output of from 10 to 15 cu yd, or from 270 to 405 cu ft, in continuous operation. However, the quantity of concrete placed in the form per hour will depend on how continuous the mixer operation is (which will depend in turn on how the batching is being done) and how rapidly the mix is transferred from the mixer to the form. This hourly quantity you will have to estimate according to your knowledge of the circumstances. Let's assume that you figure about 9 cu yd, or 243 cu ft, will be placed in the form per hour. In that case, the vertical rate of placement will be 243/30, or about 8 ft per hour.

PRESSURE FROM VERTICAL RATE OF PLACEMENT

To determine the maximum concrete pressure, the Builder must know the temperature of the concrete and the rate of placement per square foot. When a Builder knows these things he can easily find the maximum concrete pressure by using a chart such as the one shown in figure 5-1. For example, to find the maximum concrete pressure of concrete that is 70°F and has a rate of placement at 8 feet per hour, move across the top row of figures in the chart to 8 feet per hour. In this space is the maximum concrete pressure, which is 930 lbs psf.

RATE OF PLACING	2 FT. PER HOUR	3 FT. PER HOUR	4 FT. PER HOUR	5 FT. PER HOUR	6 FT. PER HOUR	7 FT. PER HOUR	8 FT. PER HOUR	9 FT. PER HOUR	10 FT. PER HOUR	11 FT. PER HOUR
TEMPERATURE 70°F - 100 LBS PSF	330	430	530	630	730	830	930	1030	1130	1230
TEMPERATURE 50°F - 100 LBS PSF	420	580	720	880	1010	1180	1310	1470	1610	1870

117.185

Figure 5-1.—Pressure from vertical rate of placement.

There are formulas available to determine pressures for any rate and temperature. Several examples are given below.

In columns:

$$P = 150 + \frac{9000R}{T}$$ (maximum 3000 psf or 150 h, whichever is least)

In walls with rate not exceeding 7 ft per hour:

$$P = 150 + \frac{9000R}{T}$$ (maximum 2000 psf or 150 h, whichever is least)

In walls with rate over 7 ft per hour:

$$P = 150 + \frac{43400}{T} + \frac{2800R}{T}$$ (maximum 2000 psf or 150 h, whichever is least)

P = maximum lateral pressure
R = rate of placement (ft per hr)
T = temperature of concrete in form, °F
h = maximum height of fresh concrete.

MAXIMUM SPACING OF WALL FORM STUDS

Knowing the pressure to be expected, you determine the maximum spacing for wall form studs by reference to a chart such as the one shown in figure 5-2. This chart is related to board sheathing and plywood sheathing. Suppose you want to know the maximum stud spacing when using 1-inch board sheathing with a concrete pressure of 500 pounds per square foot. Referring to the chart in figure 5-2, move across the first row of figures until the maximum concrete pressure of 500 psf is reached, and there you will find the maximum stud spacing of 18 inches.

It is believed by some that 3/4-inch plywood sheathing is as strong as 1-inch board sheathing. Note that we stated "it is believed" to be as strong, but our chart shows it is not so. To prove this point, move across the sixth row of figures in figure 5-2 until the maximum concrete pressure of 500 psf is reached again. There you will see the number 15, which proves that the spacing for the studs would have to be closer; therefore, plywood is not as strong as board sheathing. However, plywood does have a great advantage because, with reasonable care,

MAXIMUM CONCRETE PRESSURE	100 LBS PER SQUARE FOOT	200 LBS PER SQUARE FOOT	300 LBS PER SQUARE FOOT	400 LBS PER SQUARE FOOT	500 LBS PER SQUARE FOOT	600 LBS PER SQUARE FOOT	700 LBS PER SQUARE FOOT	800 LBS PER SQUARE FOOT	900 LBS PER SQUARE FOOT	1000 LBS PER SQUARE FOOT	1100 LBS PER SQUARE FOOT	1200 LBS PER SQUARE FOOT	1300 LBS PER SQUARE FOOT	1400 LBS PER SQUARE FOOT	1500 LBS PER SQUARE FOOT	1600 LBS PER SQUARE FOOT	1700 LBS PER SQUARE FOOT	1800 LBS PER SQUARE FOOT	1900 LBS PER SQUARE FOOT	2000 LBS PER SQUARE FOOT	2100 LBS PER SQUARE FOOT
1 INCH SHEATHING	30	24	22	19	18	17	15	15	14	14	13	13	13	13	12	12	11	11	10	10	9
1 1/4 INCH SHEATHING		32	28	26	24	22	21	20	19	19	18	17	17	17	17	16	16	16	16	14	14
1 1/2 INCH SHEATHING		38	34	31	29	27	26	25	24	23	22	21	21	21	20	20	19	19	19	18	18
2 INCH SHEATHING			40	38	36	34	32	31	30	28	27	27	26	25	25	25	24	23	23	23	22
1/2 INCH PLYWOOD SHEATHING	24	18	15	13	11	10	10	9	8												
3/4 INCH PLYWOOD SHEATHING	30	24	19	17	15	14	12	12	11	10	10	10	9	9							
1 INCH PLYWOOD SHEATHING	36	30	24	21	19	17	16	15	14	14	13	12	11	10							

117.186
Figure 5-2.—Maximum spacing of studs from pressure.

MAXIMUM CONCRETE PRESSURE	100 LBS PER SQUARE FOOT	200 LBS PER SQUARE FOOT	300 LBS PER SQUARE FOOT	400 LBS PER SQUARE FOOT	500 LBS PER SQUARE FOOT	600 LBS PER SQUARE FOOT	700 LBS PER SQUARE FOOT	800 LBS PER SQUARE FOOT	900 LBS PER SQUARE FOOT	1000 LBS PER SQUARE FOOT	1100 LBS PER SQUARE FOOT	1200 LBS PER SQUARE FOOT	1300 LBS PER SQUARE FOOT	1400 LBS PER SQUARE FOOT	1500 LBS PER SQUARE FOOT	1600 LBS PER SQUARE FOOT	1700 LBS PER SQUARE FOOT	1800 LBS PER SQUARE FOOT	1900 LBS PER SQUARE FOOT	2000 LBS PER SQUARE FOOT	2100 LBS PER SQUARE FOOT	2200 LBS PER SQUARE FOOT	2300 LBS PER SQUARE FOOT
2 X 4 STUDS - 1 INCH SHEATHING	40	33	27	23	20	17	16	14	13	12	11	10	10	10	9	9	9						
2 X 4 STUDS - 1¼ INCH SHEATHING	52	46	36	31	27	24	21	19	19	17	16	15	14	13	12	12	12						
2 X 6 STUDS - 1 INCH SHEATHING	66	64	56	45	40	35	32	29	27	25	24	23	22	20	19	18	17	17	17	16	15		
2 X 6 STUDS - 1¼ INCH SHEATHING	66	64	64	54	48	43	40	36	33	30	29	27	25	24	23	22	21	20	20	19	19	19	
2 X 6 STUDS - 1½ INCH SHEATHING	66	66	65	65	64	58	52	48	44	42	39	37	35	33	31	29	27	26	25	24	22	20	18
2 X 8 STUDS - 1 INCH SHEATHING									66	60	56	52	48	46	43	42	40	38	36	32	30	27	24

117.187
Figure 5-3.—Maximum wale spacing.

it can be reused several times and less manpower is needed. (Note: The chart refers to plyforms with the face grain across the supports.)

MAXIMUM SPACING OF WALL FORM WALES

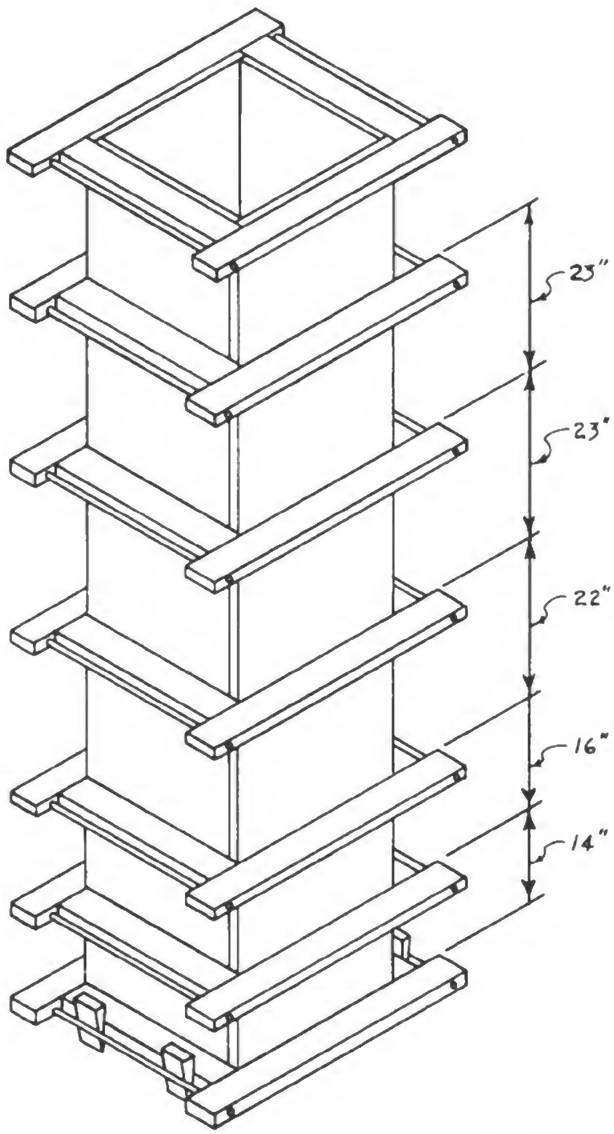
When you know the size of the studs, sheathing, and maximum concrete pressure, the maximum wale spacing is not difficult to determine using a chart such as that shown in figure 5-3. For example, suppose you want to find the maximum wale spacing for 2 x 4 studs, 1-1/4-inch sheathing, and a concrete pressure of 600 pounds per square foot. Move down the extreme left-hand column of the chart (fig. 5-3) to the second line reading "2 x 4 studs—1-1/4 inch sheathing." There, move across to the right on the immediate line to the point where the "maximum concrete pressure" column at the top of the chart reads "600 lbs psf." Now note that the block here shows the maximum wale spacing, in this case, as 24 inches.

SPACING OF COLUMN YOKES

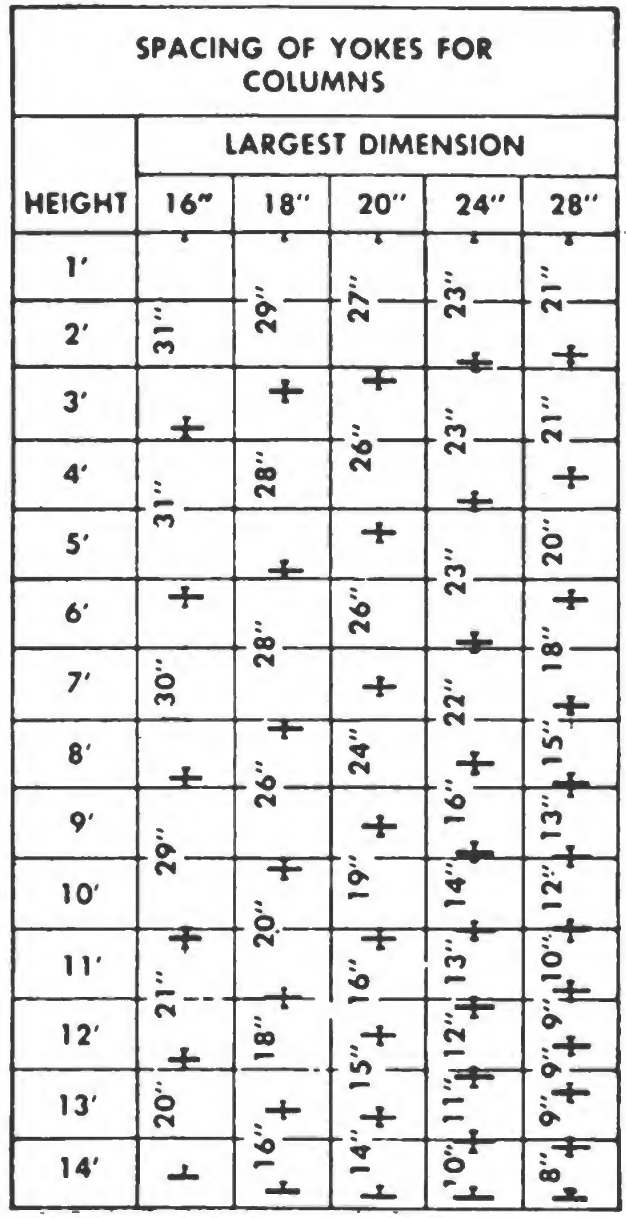
Because of the relatively small horizontal section area, the rate of placement in a column form is extremely high. Suppose you are placing a column 2 ft by 2 ft in section area and 10 ft high. If the quantity of concrete arriving in the form per hour is 9 cu yd or 243 cu ft, the rate of placement is 243/4, or more than 60 ft per hr. This creates very high lateral pressure in the form.

The yoke bracing used on a column form is strongly made to take care of this. However, the number of yokes must be sufficient, and yokes at the bottom of the form (where the pressure is highest) must be spaced more closely than yokes at the top.

Assume that the form shown in figure 5-4 is for a column 2 ft by 2 ft in section area and 10 ft high. To determine the yoke spacing you refer to a table like the one shown in figure 5-5. The lowest yoke is placed as near the bottom of the form as possible. To use the table, take the height of the column in feet at the side, and run across to the column of figures headed by the column's largest dimension in inches. The figure you find there (in this case, 14 in.) is the vertical distance between the lowest and the next highest yokes. Reading upward, you get the spacings for the yokes above (in this case, the next yoke above is 16 in. from the second, the next above that 22 in. up, and the others to the next below the top 23 in. apart). The yokes are so spaced in figure 5-4.



45.472
Figure 5-4.—Spacing of column yokes.



117.79
Figure 5-5.—Table for spacing yokes in column form.

JOIST SPACING FOR FLOOR SLAB FORMS

For joist spacing for floor slab forms, you enter a table like the one for 2 x 6 joists shown in figure 5-6 with the thickness of the slab and the span of a joist—that is, the horizontal distance between the form girders. Suppose the slab thickness is 6 in. and the joist span 8 ft. The table shows that 2 x 6 form joists should be spaced 2 ft 0 in. O.C.

CONCRETE BATCH PLANTS

In Builder 3 & 2 the methods of batching and mixing concrete by hand or in mechanical mixers loaded from dump trucks are described. When large quantities of concrete are involved, BATCHING (the weighing out of proper proportions of

SLAB THICKNESS	JOIST SPAN IN FEET						
	4	5	6	7	8	9	10
4"	4'0"	4'0"	4'0"	4'0"	4'0"	3'0"	2'6"
5"	4'0"	4'0"	4'0"	3'6"	3'0"	2'0"	2'0"
6"	4'0"	3'0"	2'6"	2'0"	2'0"	2'0"	2'0"

117.80

Figure 5-6.—Table for determining 2 x 6 joist spacing for floor slab forms.

dry ingredients) is usually done in a BATCH PLANT. A batch plant may consist only of hoppers equipped for weighing out aggregate; a complete batch plant contains, besides the aggregate hoppers, a cement SILO for weighing out cement in bulk as well. For a batch plant containing only aggregate hoppers, sacked rather than bulk cement is used. Sacked cement is used almost exclusively by the Seabees.

In a typical batch plant, one hopper, or one compartment in a hopper, contains fine aggregate. One or more other compartments or hoppers contain coarse aggregate, each individual hopper covering a size range if there is more than one hopper or compartment for coarse aggregate. For example: one coarse hopper may contain coarse from size No. 4 to 3/4, another coarse from size 3/4 to size 1-1/2. For a specific batch quantity, these will be combined, as explained later, to attain the most desirable possible gradation of the coarse aggregate.

In the larger plants, each hopper may be equipped with a scale, located on an elevated WEIGHING PLATFORM. Each compartment in a hopper may have below it a SCALE BIN, into which the aggregate in the compartment can be released for weighing by the operation of a lever. When the scale indicates the desired weight, the flow into the scale bin is cut off. By the operation of another lever, the aggregate in the weighing bin can be released to flow into a truck or a mixer below. The hoppers generally used in the battalions have only one scale. One of the two types of aggregate (coarse or fine) is weighed first, then the other type is released into the bin until the total weight equals the required sum of the two types of aggregate.

A cement silo is similarly equipped for weighing out bulk cement. If bagged cement is used, the appropriate number of sacks for a batch is dumped into the bin. If the batch plant is designed to supply transit-mix trucks, a truck may be brought under a coarse aggregate hopper first, under a sand hopper next, and under a cement hopper last. In most plants, however, the materials from the separate hoppers (or compartments) are discharged through one bin into the truck which has to make only one stop. A batch plant may have its own mixer, in which case the whole rig is called a READY MIX plant. A plant of this type discharges the weighed dry ingredients into the mixer; it is also, of course, equipped with a water tank and mechanism for measuring required quantities of water into the mixer. A plant of this type discharges ready-mixed concrete into dump trucks or agitator trucks.

CEMENT STORAGE

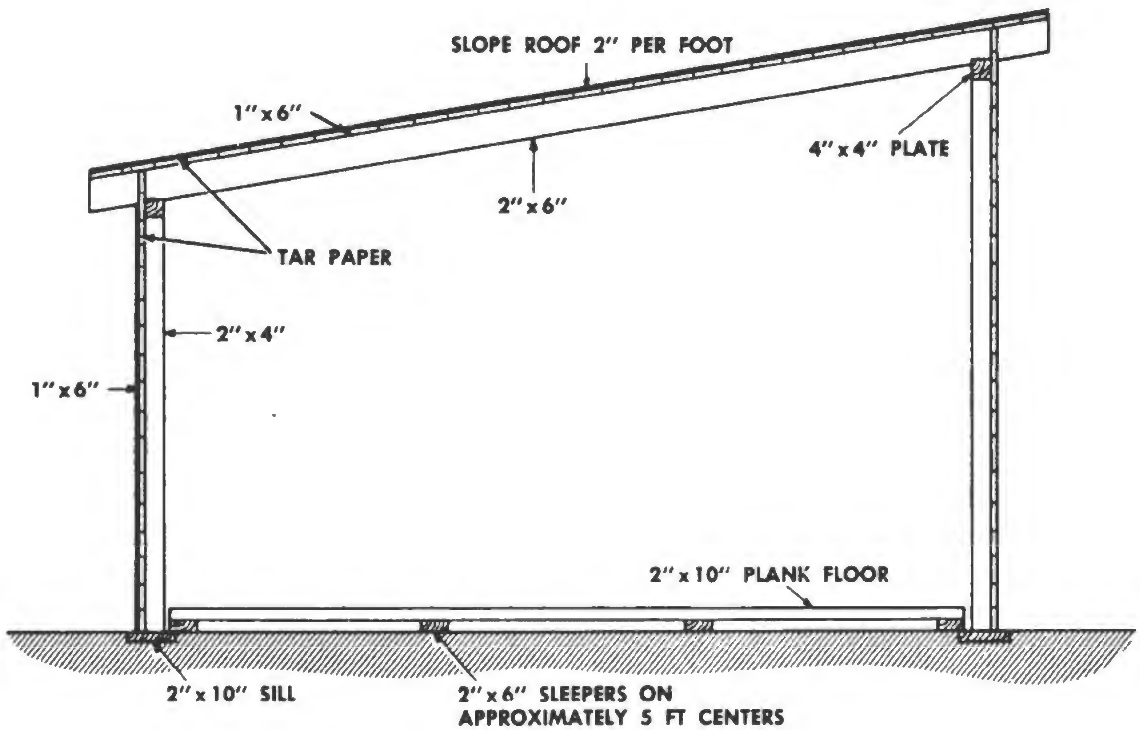
In a plant with a cement silo, bulk cement in railroad cars or trucks is discharged from a car or truck into the lower or feed end of a SCREW CONVEYOR; the conveyor carries the cement to the top of the silo and dumps it into the storage hopper.

In a plant using sacked cement, cement which will lie a long time in storage must be stored in a warehouse or shed which is as airtight as possible. The floor of the shed should be above ground, and there should be no cracks or other openings in the walls. To prevent air circulation around the sacks, the shed should be kept as nearly full as possible, and sacks should be close-stacked. Figure 5-7 shows a typical cement storage shed.

For temporary storage of sacked cement at the batch plant a platform should be built above the ground, and the cement should be stacked on the platform, under a tarpaulin.

AGGREGATE STORAGE

Coarse aggregate, screened into the required size ranges, is stored in STOCKPILES near the batch plant. It may be carried up and dumped into the storage hoppers by belt conveyor, or, as is usually done in the Seabees, by clamshell. A grade separation may be created by a combination of cutting and ramping so that the transit mix trucks can be driven under the hopper and the hoppers filled from the upper level by trucks or a front end loader. In the building up of a stockpile, care must be taken to avoid SEGREGATION of the aggregate—meaning, a tendency of aggregate, when it is transported



117.81
Figure 5-7.—Cement storage shed.

and handled, to accumulate by sizes. Figure 5-8 illustrates this tendency and shows methods of preventing it.

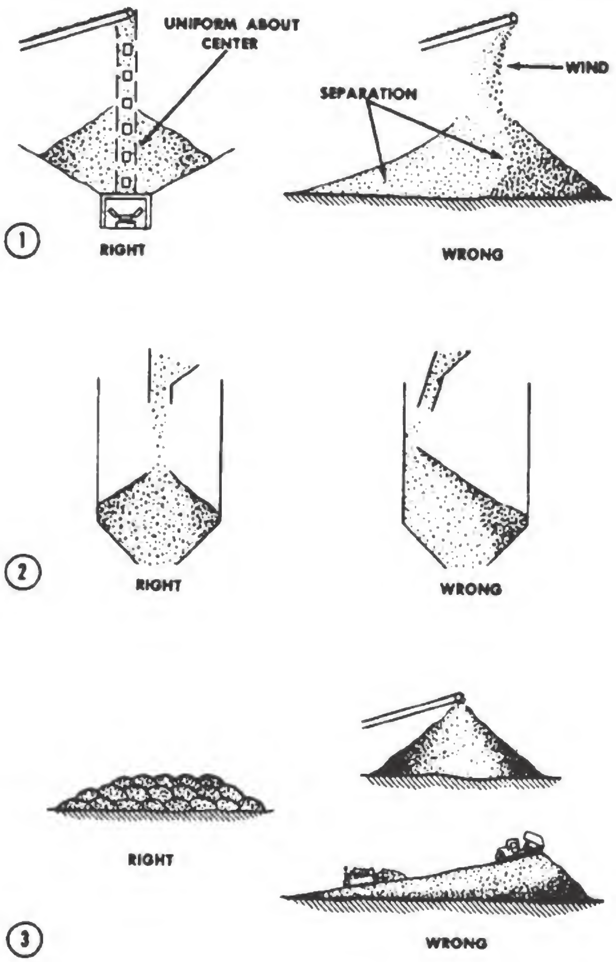
A stockpile should be built up in layers, rather than being allowed to accumulate in a cone. Material should likewise be removed from the pile in layers. Material being dropped into a storage bin should be dropped directly over the outlet of the bin, not allowed to cascade off the sides.

CONCRETE MIXES AND BATCHING

Constructionman introduced the fundamentals of the ingredients of concrete and of concrete construction. Builder 3 & 2 provided further details of the characteristics of good concrete and stressed the importance of proper batching, mixing, handling, placing, finishing, and curing. The characteristics of concrete should be considered on a relative basis and in terms of the degree of quality required for a given construction project. Figure 5-9 shows some of the properties of good concrete, their interrelationships, and various elements which control the properties. A study of this figure points up the relative basis of the characteristics. A single batch of concrete cannot possess the maximum of strength, durability, and economy. For example, entrained air makes handling easier and is therefore conducive to economy; entrained air promotes watertightness; but entrained air makes concrete less dense and thereby reduces the strength. The goal is to achieve an optimum balance of all the elements. A thorough discussion of all the factors involved in the production of good concrete is beyond the scope of this book. There is a wealth of information available to you in government and commercial publications.

CONTROL OF CONCRETE MIXTURES

The design of or selection of a mix, the necessity for a trial mix, the methods of controlling the mix proportions, and the units of



117.82
Figure 5-8.—Aggregate storage.

measure to be used in the batching all depend on the nature and size of the job and the extent to which requirements are set forth in specifications or on the plans.

An example of the simplest form of concrete batching is the mixing of a very small amount of concrete using the 1:2:4 carpenter's mix. The relative volumes of cement, sand, and gravel could be measured in bucketfuls, or even in shovelfuls, and sufficient water added to give reasonable consistency. A more refined procedure is to fabricate a one-cubic-foot wooden measuring box to give you greater control over the proportions of the ingredients. To mix approximately one cubic yard of 1:2:4 concrete, you use the Rule of 42:

Cement	4 + 2	6 bags
Sand	2 x 6	12 cubic feet
Gravel	4 x 6	24 cubic feet
		42 cubic feet of material

In addition to the carpenter's mix, there are other popular rule-of-thumb mixes:

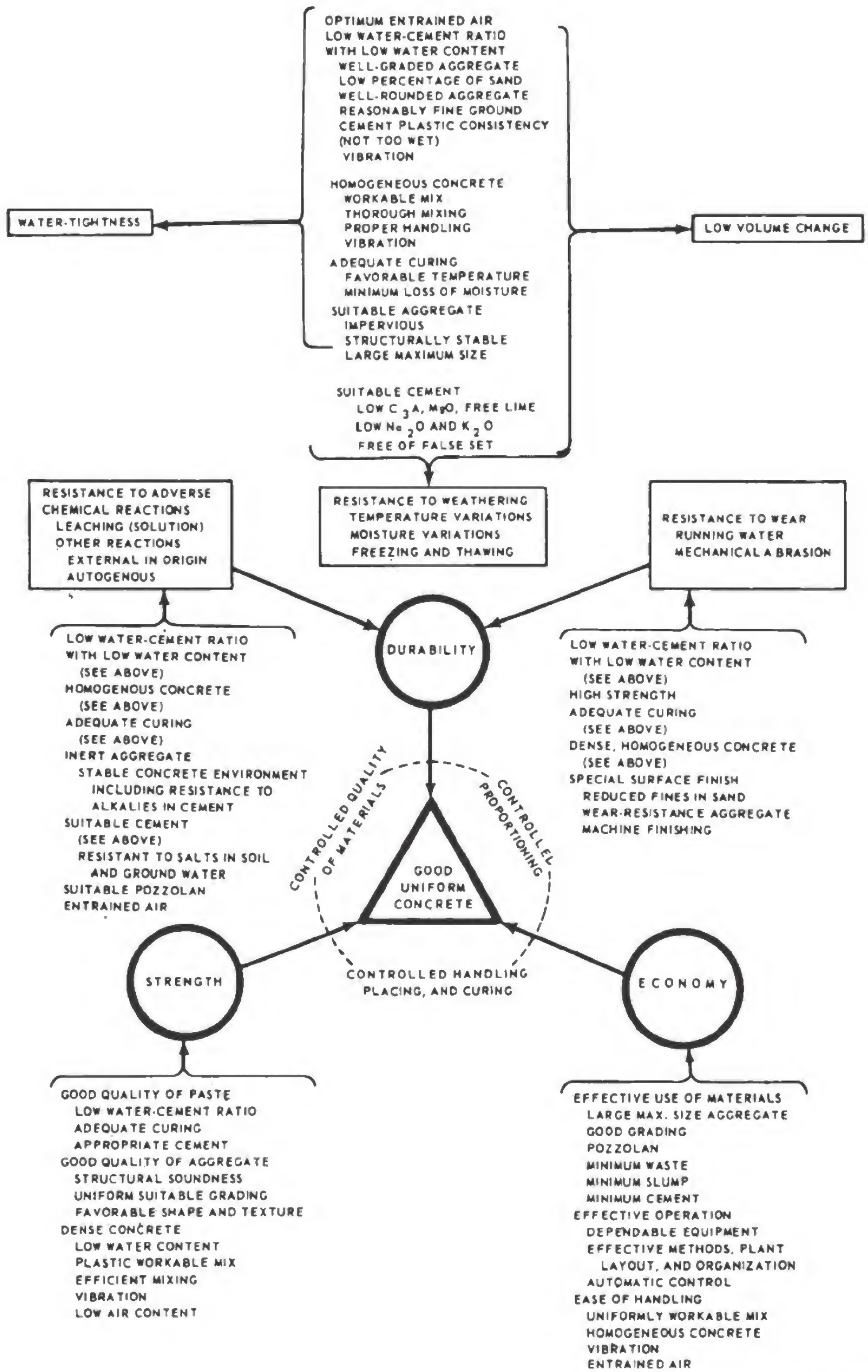
1:1:2—a very rich mix—use when great strength is required
1:2:5—a medium mix—use in large slabs and walls
1:3:5—a lean mix—use in large foundations or as a backing for masonry
1:4:8—a very lean mix—use only in mass placings.

One additional step up the ladder of controlled concrete mixes is represented by tables such as that shown in figure 5-10. In these mixes, the size of the aggregate, air entrainment, the proportion of sand, and the dampness of the sand are all considered. Note that the aggregate quantities are given in pounds. You can convert these weights to relative volumes by assuming that dry sand weighs 110 pounds per cubic foot and that gravel weighs 100 pounds per cubic foot. For example, for 1-1/2-inch aggregate, air-entrained cement, and the A mix, approximately one cubic yard of concrete will contain the following:

Cement		6 bags
Sand	6 x 225 = 1350 lbs; divide by 110:	12.3 cu ft
Gravel	6 x 290 = 1740 lbs; divide by 100:	17.4 cu ft

Here, again, you will note that "just enough" water is to be added to produce a "sufficiently workable consistency." Thus, very little control is exercised over the quantity of water and, therefore, the water-cement ratio.

The other extreme of controlled concrete mixes and batching might be represented by the methods used on a project as large as the Hoover Dam. Both central and field laboratories are constantly at work. The cement, water, and aggregates are continuously tested. Mix designs are constantly being revised as the aggregates change; great numbers of trial mixes are used in casting specimens which are subjected to many different tests. In the field, tests are run to determine moisture of the aggregate; water is closely controlled; constant inspection is per-



117.83
Figure 5-9.— Principal properties of good concrete and their relationship.

MAXIMUM SIZE OF AGGREGATE, INCHES	MIX DESIGNATION	APPROXIMATE BAGS CEMENT PER CUBIC YARD OF CONCRETE	POUNDS OF AGGREGATE PER 1-BAG BATCH		
			SAND[2]		GRAVEL OR CRUSHED STONE
			AIR-ENTRAINED CONCRETE[3]	CONCRETE WITHOUT AIR	
1/2	A	7.0	235	245	170
	B	6.9	225	235	190
	C	6.8	225	235	205
3/4	A	6.6	225	235	225
	B	6.4	225	235	245
	C	6.3	215	225	265
1	A	6.4	225	235	245
	B	6.2	215	225	275
	C	6.1	205	215	290
1 1/2	A	6.0	225	235	290
	B	5.8	215	225	320
	C	5.7	205	215	345
2	A	5.7	225	235	330
	B	5.6	215	225	360
	C	5.4	205	215	380

1 PROCEDURE; SELECT THE PROPER SIZEOF AGGREGATE. THEN, USING MIX B, ADD JUST ENOUGH WATER TO PRODUCE A SUFFICIENTLY WORKABLE CONSISTENCY. IF THE CONCRETE APPEARS TO BE UNDERSANDED, USE MIX A; AND IF IT APPEARS TO BE OVERSANDED, USE MIX C.

2 WEIGHTS ARE FOR DRY SAND. IF DAMP SAND IS USED, INCREASE THE WEIGHT OF SAND 10 POUNDS FOR A 1-BAG BATCH, AND IF VERY WET SAND IS USED, ADD 20 POUNDS FOR A 1-BAG BATCH.

3 IN GENERAL, AIR-ENTRAINED CONCRETE SHOULD BE USED IN ALL STRUCTURES THAT WILL BE EXPOSED TO ALTERNATE CYCLES OF FREEZING AND THAWING.

117.84

Figure 5-10.—Concrete mixes for small jobs.

formed on methods of batching, mixing, handling, placing, and curing.

Most concrete work done by the Seabees falls between these two extremes. But whether the mix proportions are determined after extensive trials and tests, or whether the proportions are based on limited requirements (such as a required strength) shown on the plans combined with field experience, there are basic considerations which must always be made in order to do an economical job. Mix proportions should be selected to produce concrete with:

1. The stiffest consistency (maximum amount of coarse aggregate) that can be placed efficiently with vibration to provide a homogeneous mass.

2. The maximum size of aggregate economically available and consistent with job requirements.

3. Adequate durability to withstand satisfactorily the weather and other destructive agencies to which it may be exposed.

4. Sufficient strength to withstand without danger of failure the loads to be imposed.

A minimum slump consistent with required workability should be selected. (For representative slumps, see the table in figure 5-14.) The required workability determines the quantity of water; for a given water requirement, quality of concrete is proportional to cement content. The maximum water-cement ratio (that is, the minimum amount of cement) should be selected consistent with the requirements for durability and strength. Figures 5-11 and 5-12 are typical of tables which relate the water-cement ratio to durability and strength. Figure 5-13 is typical of maximum aggregate size recommendations. In many cases, however, the closeness of the reinforcing steel limits the aggregate size. A general

TYPE OR LOCATION OF CONCRETE OR STRUCTURE, AND DEGREE OF EXPOSURE	WATER CEMENT RATIO BY WEIGHT	
	SEVERE CLIMATE, WIDE RANGE OF TEMPERATURE. LONG PERIODS OF FREEZING OR FREQUENT FREEZING AND THAWING	MILD CLIMATE, RAINY OR ARID, RARELY SNOW OR FROST
A. CONCRETE IN PORTIONS OF STRUCTURES SUBJECT TO EXPOSURE OF EXTREME SEVERITY, SUCH AS THE TOP 2 FEET OF WALLS. BOXES, PIERS, AND PARAPETS, ALL OF CURBS, SILLS, LEDGES, COPINGS, CORNERS AND CORNICES; AND CONCRETE IN THE RANGE OF FLUCTUATING WATER LEVELS OR SPRAY. THESE ARE PARTS OF DAMS, SPILLWAYS, WASTEWAYS, BLOWOFF BOXES, TUNNEL INLETS AND OUTLETS, TAILRACE WALLS, VALVE HOUSES, CANAL STRUCTURES, AND OTHER CONCRETE WORK.	0.45±0.02-------	0.55±0.02.
B. CONCRETE IN EXPOSED STRUCTURES AND PARTS OF STRUCTURES WHERE EXPOSURE IS LESS SEVERE THAN IN A, SUCH AS PORTIONS OF TUNNEL LININGS AND SIPHONS SUBJECT TO FREEZING, THE EXTERIOR OF MASS CONCRETE, AND THE OTHER EXPOSED PARTS OF STRUCTURES NOT COVERED BY A.	0.50±0.02---------	0.55±0.02.
C. CONCRETE IN STRUCTURES OR PARTS OF STRUCTURES TO BE COVERED WITH BACKFILL, OR TO BE CONTINUALLY SUBMERGED OR OTHERWISE PORTECTED FROM THE WEATHER, SUCH AS CUTOFF WALLS, FOUNDATIONS, AND PARTS OF SUBSTRUCTURES, DAMS, TRASHRACKS, GATE CHAMBERS, OUTLET WORKS, AND CONTROL HOUSES. (IF SEVERE EXPOSURE DURING CONSTRUCTION APPEARS LIKELY TO LAST SEVERAL SEASONS, REDUCE W/C FOR PARTS MOST EXPOSED BY 0.05.)	0.58±0.02--------	0.58±0.02.
D. CONCRETE THAT WILL BE SUBJECT TO ATTACK BY SULFATE ALKALIES IN SOIL AND GROUND WATERS, AND WILL BE PLACED DURING MODERATE WEATHER.	-------------------------	0.50±0.02.
E. CONCRETE THAT WILL BE SUBJECT TO ATTACK BY SULFATE ALKALIES IN SOIL AND GROUND WATERS, BUT WILL BE PLACED DURING FREEZING WEATHER, WHEN CALCIUM CHLORIDE WOULD NORMALLY BE USED IN MIX. DO NOT EMPLOY $CaCl_2$, BUT DECREASE W/C TO THE VALUE SHOWN.	0.45±0.02.	--------------------
F. CONCRETE DEPOSITED BY TREMIE IN WATER-------------------------------	0.45±0.02----------	0.45±0.02.
G. CANAL LINING---	0.53±0.02-----------	0.58+0.02.
H. CONCRETE FOR THE INTERIOR OF DAMS------------------------------------	THE PROPERTIES OF THIS CONCRETE WILL BE GOVERNED BY THE STRENGTH, THERMAL PROPERTIES, AND VOLUME CHANGE REQUIREMENTS WHICH WILL BE ESTABLISHED FOR EACH STRUCTURE.	

117.85

Figure 5-11.—Net water-cement ratios for concrete.

rule is that maximum aggregate size not exceed two-thirds of the minimum clear distance between reinforcement bars. Trial proportions of fine and coarse aggregate may be selected from tables such as that shown in figure 5-14.

Despite all of the valuable references, however, there is one document which should be your basic bible on concrete: NavFac Specification 13Y. As of the end of 1967, the current edition is 13Yh; but watch for subsequent revisions. In addition to the basic specifications, the 13Y publication contains "Notes on the use of this specification" and "Notes for the inspector." These notes will help you know what to look for on the plans and in the specifications, and what to watch out for during construction. Figure 5-15 shows a portion of a table from 13Yh. As stated in the specifications, the aggre-

WATER-CEMENT RATIO BY WEIGHT	COMPRESSIVE STRENGTH AT 28 DAYS	
	AIR-ENTRAINED CONCRETE	NON-AIR-ENTRAINED CONCRETE
0.40	4,300	5,400
0.45	3,900	4,900
0.50	3,500	4,300
0.55	3,100	3,800
0.60	2,700	3,400
0.65	2,400	3,000
0.70	2,200	2,700

117.86

Figure 5-12.—Probable minimum average compressive strength of concrete for various water-cement ratios, pounds per square inch.

gate proportions are given as a guide for determination of the proper proportions of the mix. The weights shown may be used to mix a 1-bag trial batch.

AGGREGATE GRADATION

A well-graded aggregate is important to a concrete mix. A well-graded aggregate is one in which, over the size range, there is no outsize surplus or shortage of a particular size.

The gradation of a well-graded aggregate is called DESIRABLE gradation. Desirable gradations for coarse and fine aggregate for concrete designed for various uses have been determined, and are available in tables.

In a construction battalion batching plant, the EXISTING gradations of the materials available in the aggregate bins is determined by the Inspection and Testing Section by means of sieve analysis. By comparing the existing gradations with desirable gradation, the proportion of coarse aggregate for a particular batch which should be taken from each bin to attain desirable gradation (or a near approach to it) can be determined. If there is more than a single bin of fine aggregate, the same procedure is followed with the fine.

MINIMUM DIMENSION OF SECTION, INCHES	MAXIMUM SIZE OF AGGREGATE,[1] IN INCHES FOR—		
	REINFORCED WALLS, BEAMS, AND COLUMNS	HEAVILY REINFORCED SLABS	LIGHTLY REINFORCED OR UNREINFORCED SLABS
5 OR LESS	----------	3/4 TO 1 1/2	3/4 TO 1 1/2
6 TO 11	3/4 TO 1 1/2	1 1/2	1 1/2 TO 3
12 TO 29	1 1/2 TO 3	3	3 TO 6
30 OR MORE	1 1/2 TO 3	3	6

[1]BASED ON SQUARE SCREEN OPENINGS.

117.87

Figure 5-13.—Maximum sizes of aggregate recommended for various types of construction.

ADJUSTMENTS FOR MOISTURE

The BASIC MIX proportions for the concrete for a particular structure are prescribed in the specifications. Let's suppose that for a certain structure a trial batch contains basic mix proportions of 5.5 gals of water, 94 lbs of cement, 188 lbs of fine aggregate, and 316 lbs of coarse aggregate.

Now, these proportions are based on the assumption of SATURATED SURFACE-DRY condition of the aggregate—meaning that the aggregate is assumed to contain all the water it is capable of absorbing, but no so-called FREE water over and above that. Aggregate in this condition will use all of the water added at the mixer for cement hydration; that is, the water-cement ratio attained will be that desired by the designers. However, if the moisture content were less than that required for saturated surface-dry condition, then some of the water added at the mixer would be absorbed by the aggregate; in which case, of course, the water-cement ratio would be lower than the design ratio. If, on the other hand, free water existed in the aggregate, then the water-cement ratio, after the addition of the specified amount of water at the mixer, would be higher than the design ratio. Assuming the design ratio to be the optimum required for the highest strength consistent with workability, in either case the quality of the concrete would be less than it should be.

Specification 13Yh requires that accurate procedures be established for determining the quantities of free moisture in the aggregate. The moisture content of aggregate—especially of fine aggregate— is seldom, if ever, less than that required for saturated surface-dry condition. However, aggregate practically always contains some free water over and above that required for saturated surface-dry condition. If the amount of this free water is significant, then it must be taken into account. For example: suppose that the basic mix formula calls for 5.5 gals of water and 188 lbs of sand, and that the available sand already contains 4 percent of free water by weight. This means that to get

Maximum size coarse aggregate	Water-cement ratio in US gal per sack	Proportions by surface dry wt				Surface dry wt of aggregate per sack of cement (lb)		Proportions by vol (cu ft)			Yield cu ft concrete per sack cement
		Slump (in.)	Cement	Fine aggregate	Coarse aggregate	Fine	Coarse	Cement	Fine agg. (dry comp)	Coarse agg. (dry comp)	
1-inch	5	½ to 1	1	2.0	3.1	188	291	1	1.7	2.8	4.07
		3 to 4	1	1.7	2.5	160	235	1	1.5	2.2	3.56
		5 to 7	1	1.4	2.0	132	188	1	1.2	1.8	3.11
	5½	½ to 1	1	2.2	3.4	206	320	1	1.9	3.0	4.40
		3 to 4	1	1.9	2.9	180	272	1	1.6	2.6	3.95
		5 to 7	1	1.6	2.3	150	216	1	1.4	2.1	3.50
	6	½ to 1	1	2.5	3.8	235	357	1	2.2	3.4	4.92
		3 to 4	1	2.2	3.4	206	320	1	1.9	3.3	4.47
		5 to 7	1	1.9	2.8	180	262	1	1.6	2.5	3.95
	6½	½ to 1	1	2.8	4.1	262	387	1	2.4	3.7	5.32
		3 to 4	1	2.5	3.7	235	348	1	2.1	3.3	4.86
		5 to 7	1	2.2	3.3	206	310	1	1.9	3.0	4.54
	7	½ to 1	1	3.0	4.3	282	405	1	2.6	3.9	5.63
		3 to 4	1	2.7	4.0	254	386	1	2.3	3.6	5.24
		5 to 7	1	2.4	3.6	226	340	1	2.1	3.2	4.86
	8	½ to 1	1	3.4	4.9	320	460	1	2.9	4.4	6.29
		3 to 4	1	3.1	4.7	290	440	1	2.7	4.2	6.04
		5 to 7	1	2.8	4.4	262	415	1	2.4	3.9	5.64
1½-inch	5	½ to 1	1	1.9	3.3	175	310	1	1.6	3.0	4.09
		3 to 4	1	1.7	3.1	160	290	1	1.5	2.8	3.85
		5 to 7	1	1.5	2.8	145	262	1	1.3	2.5	3.01
	5½	½ to 1	1	2.1	3.6	200	340	1	1.8	3.2	4.49
		3 to 4	1	2.0	3.3	188	310	1	1.7	3.0	4.22
		5 to 7	1	1.8	3.1	168	290	1	1.5	2.8	4.00
	6	½ to 1	1	2.4	3.9	226	366	1	2.1	3.5	4.87
		3 to 4	1	2.2	3.7	206	348	1	1.9	3.3	4.64
		5 to 7	1	2.1	3.4	200	320	1	1.8	3.0	4.43
	6½	½ to 1	1	2.7	4.2	254	390	1	2.3	3.8	5.23
		3 to 4	1	2.5	3.9	235	366	1	2.1	3.5	4.99
		5 to 7	11	2.3	3.6	218	340	1	2.0	3.2	4.73
	7	½ to 1	11	3.0	4.6	282	433	1	2.6	4.1	5.76
		3 to 4	1	2.8	4.2	262	395	1	2.4	3.8	5.40
		5 to 7	1	2.6	3.9	246	366	1	2.2	3.5	5.12
	8	½ to 1	1	3.3	4.7	310	440	1	2.8	4.2	6.10
		3 to 4	1	3.1	4.4	290	415	1	2.6	4.0	5.82
		5 to 7	1	2.9	4.0	272	386	1	2.5	3.7	5.53
2-inch	5	½ to 1	1	2.0	3.7	188	348	1	1.7	3.3	4.40
		3 to 4	1	1.7	3.0	160	282	1	1.5	2.7	3.88
		5 to 7	1	1.4	2.5	132	235	1	1.2	2.2	3.36
	5½	½ to 1	1	2.3	3.9	218	366	1	2.0	3.5	4.79
		3 to 4	1	2.0	3.4	188	320	1	1.7	3.0	4.30
		5 to 7	1	1.7	2.9	160	272	1	1.5	2.6	3.88
	6	½ to 1	1	2.6	4.4	246	415	1	2.2	3.9	5.24
		3 to 4	1	2.2	3.8	206	357	1	1.9	3.4	4.73
		5 to 7	1	2.0	3.4	188	320	1	1.7	3.0	4.34
	6½	½ to 1	1	2.8	4.7	262	440	1	2.4	4.2	5.64
		3 to 4	1	2.5	4.2	235	396	1	2.1	3.8	5.18
		5 to 7	1	2.2	3.8	206	357	1	1.9	3.4	4.80
	7	½ to 1	1	3.0	5.0	282	470	1	2.6	4.5	6.03
		3 to 4	1	2.7	4.5	254	422	1	2.3	4.0	5.51
		5 to 7	1	2.4	4.1	226	387	1	2.1	3.7	5.18
	8	½ to 1	1	3.4	5.5	320	516	1	2.9	4.9	6.62
		3 to 4	1	3.1	5.1	290	480	1	2.7	4.6	6.29
		5 to 7	1	2.8	4.6	262	432	1	2.4	4.1	5.77

117.89

Figure 5-14.— Trial mix proportions.

CLASS OF CONCRETE (FIGURES DENOTE SIZE OF COARSE AGGREGATE IN INCHES)	ESTIMATED 28-DAY COMPRESSIVE STRENGTH, (POUNDS PER SQUARE INCH)	CEMENT FACTOR, BAGS (94 POUNDS) OF CEMENT PER CUBIC YARD OF CONCRETE, FRESHLY MIXED	MAXIMUM WATER PER BAG (94 POUNDS) OF CEMENT (GALLONS)	FINE AGGREGATE RANGE IN PERCENT OF TOTAL AGGREGATE BY WEIGHT	APPROXIMATE WEIGHTS OF SATURATED SURFACE-DRY AGGREGATES PER BAG (94 POUNDS) OF CEMENT[2]	
					FINE AGGREGATE (POUNDS)	COARSE AGGREGATE (POUNDS)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
F-0.375	3,500	9.15	4.25	44-52	134	154
F-0.5	3,500	8.60	4.25	35-43	120	187
F-0.75	3,500	7.65	4.50	34-42	141	229
F-1	3,500	7.15	4.50	29-37	135	273
F-1.5	3,500	6.40	4.75	27-35	148	330
F-2	3,500	6.05	4.75	25-33	150	367
F-2.5	3,500	5.80	4.75	23-31	148	400
F-3.5	3,500	5.40	5.00	22-30	157	447
G-0.375	4,000	10.20	3.75	41-49	109	134
G-0.5	4,000	9.55	3.75	32-40	997	173
G-0.75	4,000	8.45	4.00	31-39	115	214
G-1	4,000	7.95	4.00	27-35	112	249
G-1.5	4,000	7.10	4.25	25-33	123	301
G-2	4,000	6.65	4.25	23-31	126	339
G-2.5	4,000	6.40	4.25	21-29	123	367
G-3.5	4,000	5.90	4.50	20-28	132	416

117.88

Figure 5-15.—Table from NavFac Specification 13Yh.

188 lbs of sand you must weigh out 188 lbs + (0.04 x 188 lbs), or 188 + 7.52, or 195.52 lbs. In this 195.52 lbs of sand there exists (0.04 x 195.52), or 7.82 lbs of free water. There are 8.34 lbs of water in a gallon; therefore, the sand contains 7.82/8.34, or 0.94 gals of free water. Therefore, instead of the basic mix quantity of 5.5 gals, there would be (5.5 - 0.94), or 4.56 gals added at the mixer.

Determining Moisture Content in Aggregate

The inspection and test section should run periodical laboratory tests to determine the percentage of water (both absorbed and free) in the aggregate. This is determined by selecting a representative sample, weighing the sample in its existing condition, then oven-drying and reweighing. If an oven is not available, the moisture may be burned off by using alcohol and a flash pan. The difference in weight before and after drying is, of course, the weight of the moisture. This weight is converted into a percentage by multiplying it by 100 and dividing the result by the oven-dry weight of the sample.

This percentage is the total percentage of water in the aggregate—that is, of both absorbed and free water. To determine how much of the percentage relates to free water, the known absorption capacity of that particular type of aggregate, in percentage by weight, is subtracted from the total percentage. The approximate capacity for water absorption of typical aggregates is as follows:

Average sand: 1 percent by weight
Calcareous pebbles and crushed limestone: 1 percent by weight
Trap rock and granite: 0.5 percent by weight
Porous sandstone: 7 percent by weight.

Field Mix from Basic Mix

The batch plant crew converts the basic mix proportions prescribed in the specifications to FIELD MIX proportions in which allowance is made for free water in the aggregate. Suppose, for example, that basic mix proportions are 5.5 gals of water, 94 lbs (1 sack) of cement, 188 lbs of sand, and 316 lbs of coarse aggregate, saturated surface-dry weights.

Assume that the fine aggregate is average sand and the coarse aggregate is calcareous pebbles and crushed limestone, both of which have an absorption capacity of 1 percent by weight. The lab reports that the total percentage of water in the sand is 6 percent, while that in the coarse aggregate is 1.5 percent.

Take the sand first. You have to adjust a basic weight of 188 lbs to a field weight which will allow for the water in the sand. You know that the TOTAL percentage of water in the sand is 6 percent by weight. The basic proportion of sand of 188 lbs is based on the assumption of saturated surface-dry condition—that is, on the assumption of sand containing all the water it is capable of absorbing, but no free water over. This sand is capable of absorbing 1 percent by weight; therefore, the percentage of free water in the sand is (6 - 1), or 5 percent. Therefore, the field mix weight of the sand is 188 + (188 x 0.05), or (188 + 9.4), or 197.4 lbs. In this 197.4 lbs of sand, there exists (0.05 x 197.4) 9.87 lbs of free water. There are 8.34 lbs of water in a gallon; therefore, the sand contains 9.87/8.34 or 1.17 gals of free water. In the case of the coarse aggregate, you add (1.5 - 1) 0.5 percent; therefore, the field mix weight of the coarse aggregate is 316 + (316 x 0.005), or (316 + 1.58), or 317.6 lbs. In this 317.6 lbs of coarse aggregate, there exists (0.005 x 317.6), or 1.59 lbs of free water.

The water proportion of the basic mix must be reduced to offset the total free water in the aggregate. If you think the matter over for a minute, you will realize that the weight of the total free water in the aggregate equals the amount by which the aggregate weight of the field mix exceeds the aggregate weight of the basic mix. You increased the sand by 9.4 lbs for a total of 10.98 lbs. Therefore, there is now 11.46 lbs of free water in the aggregate, which amounts to 11.46/8.34 or 1.37 gals. Consequently, you must reduce the basic mix water proportion of 5.5 gals by 1.37 gals, or to 4.13 gals actually added at the mixer.

The quantity of ingredients actually weighed out for each batch will depend on the capacity of the mixer which will receive the batch. In many cases, the basic batch is given in terms of the weights of the ingredients for one cubic yard of concrete. This procedure is easily used when the cement is stored in bulk; to get a 5 CY batch, for example, you simply multiply the given weights by 5. When bagged cement is used, however, there is a problem in obtaining accurate measurement of the cement. Most mixes do not contain an even number of bags per yard; so instead of trying to estimate a portion of a bag, you can round off the batch to the nearest number of bags, or the next lowest number of bags if so required by the capacity of the mixer. For example, if you are batching 13Yh class E-0.75 concrete, the cement requirement is 6.10 bags per yard. If the mixer has a 2-CY capacity, you can obtain a batch of approximately 2 CY by mixing a "twelve-sack batch." Besides, it's easier to multiply the required water per bag and aggregate per bag by 6 than by 6.10.

For the batch we have been talking about, the field mix formula is 4.2 gals of water, 1 sack of cement, 197.4 lbs of sand, and 317.6 lbs of coarse aggregate. For a 5-sack batch based on this formula, the quantities of dry aggregates actually weighed out would be (317.6 x 5) or 1588 lbs of coarse aggregate, and (197.4 x 5) or 987 lbs of sand. The amount of water added at the mixer would be (4.2 x 5) or 21 gals.

WORKABILITY

A concrete mix must be of proper consistency or WORKABLE enough to fill the form spaces of its own accord, or with the assistance of a reasonable amount of shoveling, spading, vibrating, and the like. A fluid or "runny" mix will fill intricate form spaces more readily than a non-fluid or "stiff" mix. The fluidity (that is, the consistency or workability) of a mix is tested in a SLUMP TEST, in which a cone, open at both ends, is set up on a board and filled with a sample of the mixed concrete. The cone is then removed, and the vertical distance the concrete sags or SLUMPS downward is measured. The greater the slump, the higher the workability or fluidity of the mix. You should be familiar with the procedures used in making the slump test, so the detailed procedure is not given here. Let us, however, discuss some of the factors regarding the workability of concrete which may be of concern to you.

Obviously, concrete intended for a massive structure like a dam doesn't need to be as workable as concrete which must fill narrow, intricate form spaces. Ranges of permissible slumps for some common types of concrete structures are as follows:

Type of Structure	Slump in Inches Max.	Slump in Inches Min.
Reinforced foundations, walls, and footings	5	2
Nonreinforced substructure concrete	4	1
Slabs, beams, and reinforced walls	6	3
Building columns	6	3
Pavements	3	2
Massive structures (dams, etc.)	3	1

The table in figure 5-14 gives 1-sack batch ingredient proportions for trial mixes with maximum coarse aggregate sizes of 1 in., 1-1/2 in., and 2 in. Within each aggregate size category, proportions are given for water-cement ratios from 5:1 to 8:1. For each water-cement ratio, ingredient proportions are given for slumps from 1/2 in. to 1 in., 3 in. to 4 in., and 5 in. to 7 in. In the furthest column to the right the yield (quantity of concrete obtained) from each of the 1 sack batch formulas is given.

The first thing to notice here is the fact that, the larger the maximum size of the coarse aggregate, the larger the proportion of aggregate that can be used to attain the same slump. The coarse aggregate is the cheapest dry ingredient in a mix; the sand is the next cheapest; and the cement is by far the most expensive.

The next thing to notice is the fact that, in adjustments made to increase or decrease a slump, the water-cement ratio REMAINS THE SAME. This is because the principal factor controlling the compressive strength of the concrete is the water-cement ratio. Next notice that the proportion of fine aggregate to coarse aggregate remains approximately the same. Take, for example, the three formulas given for 1-in. maximum coarse aggregate, 5:1 WC ratio. For a slump between 1/2 in. and 1 in. the proportion of fine to coarse is 188/291, or about 1:1.55. For a slump of 3 in. to 4 in. the proportion of fine to coarse is 160/235, or about 1:1.45. For a slump of 5 in. to 7 in. the proportion of fine to coarse is 132/188, or about 1:1.42. The reason this ratio remains about the same is the fact that several quality considerations—notably density—depend on the ratio of fine to coarse.

Now, the principal bulk of the mixed concrete comes from the aggregate; the cement and the water contribute only an insignificant quantity to the bulk. A glance at the table shows you that, to increase a slump, you cut down on the quantity of aggregate, while maintaining a more or less constant ratio of fine to coarse. Since the water quantity remains the same, cutting down the aggregate quantity amounts to the same thing as increasing the water quantity; thus the reason for the increase in slump is obvious.

However, a glance at the column to the far right shows you that when you increase the slump by cutting down on the aggregate, you cut down on the yield per sack of cement. This means, of course, that for a given volume of concrete, more cement (the most expensive ingredient) will be required. Therefore, the higher the slump, the more expensive the mix. For this reason, the slump prescribed in the specifications will always be the minimum consistent with workability requirements. If tests on a given formula indicate a slump higher than that specified, then it is usually economically desirable to increase the aggregate quantity, thereby decreasing both the slump and the cost of the mix. If tests on a given formula show considerably less than the specified slump, then it is usually unavoidably necessary to cut down on the aggregate quantity, thereby increasing both the slump and the cost of the mix.

MAKING SAMPLES FOR LAB TESTS

You may be called upon to mold cylinders and beams for compression and flexural tests to be run later in the lab.

The first step is to obtain a sample of the concrete. The sample should consist of not less than 1 cu ft when it is to be used for strength tests. Smaller samples may be permitted for routine air content and slump tests.

The procedures used in sampling should include the use of every precaution that will assist in obtaining samples that will be representative of the true nature and condition of the concrete sampled, as follows:

1. Sampling from Stationary Mixers, Except Paving Mixers.—The sample must be obtained by passing a receptacle completely through the discharge stream of the mixer at about the middle of the batch, or by diverting the stream

completely so that it discharges into a container. Care must be taken not to restrict the flow from the mixer in such a manner as to cause the concrete to segregate. These requirements apply to both tilting and nontilting mixers.

2. Sampling from Paving Mixers.— The contents of the paving mixer must be discharged, and the sample must be collected from at least five different portions of the pile.

3. Sampling from Revolving Drum Truck Mixers or Agitators.— The sample must be taken at three or more regular intervals throughout the discharge of the entire batch, except that samples must not be taken at the beginning or end of discharge. Sampling must be done by repeatedly passing a receptacle through the entire discharge stream, or by diverting the stream completely so that it discharges into a container. The rate of discharge of the batch must be regulated by the rate of revolution of the drum, and not by the size of the gate opening.

The sample must be transported to the place where test specimens are to be molded or where the test is to be made, and must be remixed with a shovel the minimum amount to ensure uniformity. The sample must be protected from sunlight and wind during the period between taking and using, which must not exceed 15 minutes.

Cylinders for Compressive Strength Tests

The compressive strength of concrete (that is, the ability to resist a CRUSHING force) is, as previously explained, controlled by the W-C. However, the theoretical compressive strength related to a particular W-C will be attained only if the actual amount of water added is carefully regulated in accordance with the considerations previously mentioned. To determine what compressive strength was actually attained, samples cast from the mix being used must be cured and tested.

Tests are made on 6 in. by 12 in. cylinders, cast in cylindrical molds. For the final test, a cylinder is cured for 28 days; however, the PROBABLE 28-day strength a mix will attain can be estimated by determining the 7-day strength (which usually runs about 2/3 of the 28-day strength). Therefore, one or more cylinders are tested after 7 days of curing.

Test cylinders are cast in either metal or heavy cardboard molds. For filling, a mold is placed on a metal BASE PLATE. To avoid loss of mix water, the bottom of the mold is sealed to the base plate with paraffin. A cardboard mold is expendable—that is, for stripping it is simply torn off. A metal mold is hinged, so that it can be stripped by opening. Before filling, the inside surface of the mold and base plate are lightly oiled, to prevent the concrete from BONDING (adhering) to the mold and plate.

The test specimens shall be formed by placing the concrete in the mold in three layers of approximately equal volume. In placing each scoopful of concrete, the scoop must be moved around the top edge of the mold as the concrete slides from it in order to ensure a symmetrical distribution of the concrete within the mold. The concrete must be further distributed by a circular motion of the tamping rod. Each layer must be rodded with 25 strokes of a 5/8 in. round rod, approximately 24 in. in length and tapered for a distance of 1 in. to a spherically shaped end having a radius of approximately 1/4 in. The strokes must be distributed uniformly over the cross-section of the mold and must penetrate into the underlying layer. The bottom layer must be rodded throughout its depth. Where voids are left by the tamping rod, the sides of the mold must be tapped to close the voids. After the top layer has been rodded, the surface of the concrete must be struck off with a trowel and covered with a glass or metal plate to prevent evaporation.

After about 24 hours of hardening, the mold is stripped off and the cylinder is immersed in water, moist sand, moist sawdust, or moist earth for curing. At the expiration of the curing period (7 or 28 days), the cylinder is CAPPED on both ends, with a thin layer of gypsum CASTING PLASTER or sulfur CAPPING COMPOUND. For testing, the cylinder is placed under the piston of a machine capable of applying a very high pressure (for a 6 in. diameter cylinder with a compressive strength of about 6000 psi, the rupturing pressure must reach about 170,000 lbs). Pressure is applied, and increased until the cylinder collapses.

Beams for Flexual Strength Tests

The compressive strength of concrete is its ability to resist a crushing force; the FLEXURAL strength is ability to resist a BREAKING force. The flexural strength of concrete is considerably less than its compressive strength.

For a flexural strength test a TEST BEAM, cast in a TEST BEAM MOLD like the one

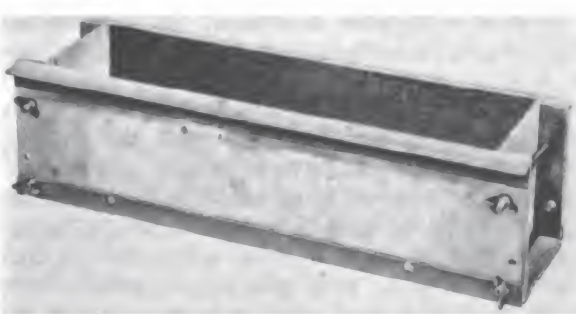
shown in figure 5-16, is cured and then broken by a BEAM BREAKER.

The test specimen must be formed with its long axis horizontal. The concrete must be placed in layers approximately 3 in. in depth and each layer must be rodded 50 times for each square foot of area. The top layer must slightly overfill the mold. After each layer is rodded, the concrete must be spaded along the sides and ends with a mason's trowel or other suitable tool. When the rodding and spading operations are completed, the top must be struck off with a straightedge and finished with a wood float. The test specimen must be made promptly and without interruption.

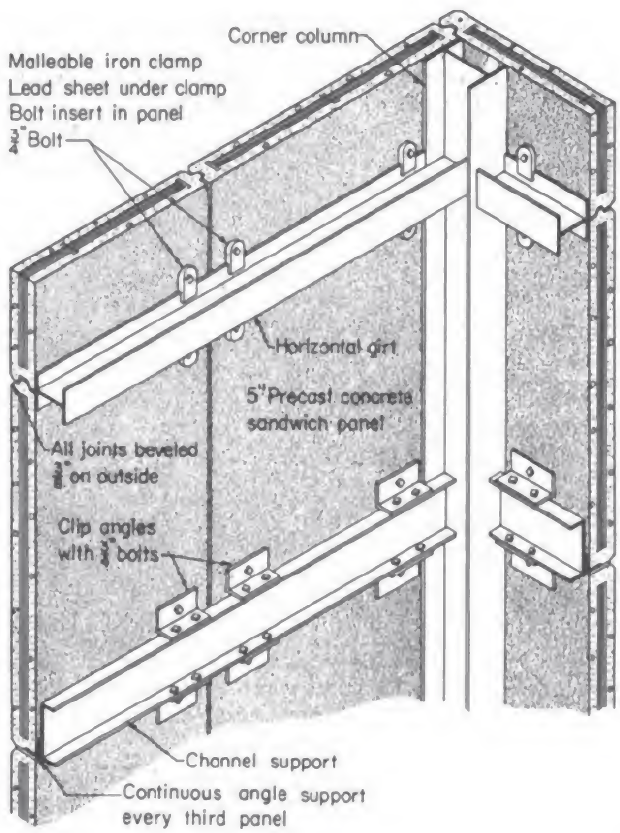
PRECAST CONCRETE

Concrete which is cast in the position which it is to occupy in the finished structure is called CAST-IN-PLACE concrete. Concrete which is cast and cured elsewhere, then transported to the site and erected as a prefabricated unit, is called PRECAST concrete.

Wall construction, for example, is frequently done with precast wall PANELS originally cast horizontally (sometimes one above the other) as slabs. This method has many advantages over the conventional method of casting in place in vertical wall forms. Since a slab form requires only edge forms and a single surface form, the amount of form work and form materials required is greatly reduced. The labor involved in slab form concrete casting is much less than that involved in filling a high wall form. One side of a precast unit cast as a slab may be finished by hand to any desired quality of finish. The placement of reinforcing steel is much easier in slab forms, and it is easier to attain thorough filling and thorough vibrating. Precasting of wall panels as slabs may be expedited by mass production methods not available when casting in place.



45.576
Figure 5-16.—Test beam mold.

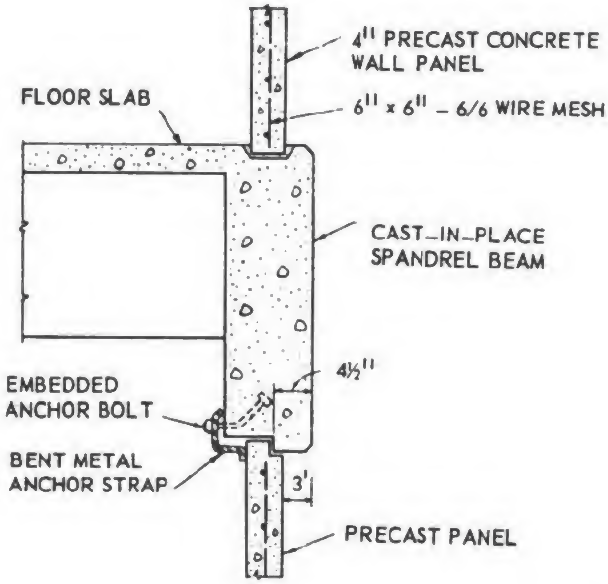


117.90X
Figure 5-17.—Method of attaching precast panels to steel framework.

Relatively light panels for nonbearing concrete walls are precast as slabs and attached to a previously erected building frame as shown in figures 5-17 (steel frame) and 5-18 (concrete frame). The panels, after transportation from the casting yard, may be set in place from outside the building by cranes, or they may be set from within by forklift truck or even by block and tackle.

CONCRETE BLOCK

Concrete block can be made by casting an ordinary plastic type of mix in forms. In this



117.91X
Figure 5-18.—Method of attaching precast panels to concrete framework.

case, however, the forms cannot be stripped until after the interval required for ordinary plastic concrete. Most concrete blocks are made in machines which permit immediate removal of the form from a green block. A block machine molds a unit by vibrating, by the application of pressure (tamping), or by a combination of both methods. In recent years, vibration has come to occupy an increasingly important position in the industry, and many of the high-capacity machines now on the market apply vibration in some manner to the mold box. Vibration improves density, strength, and surface texture.

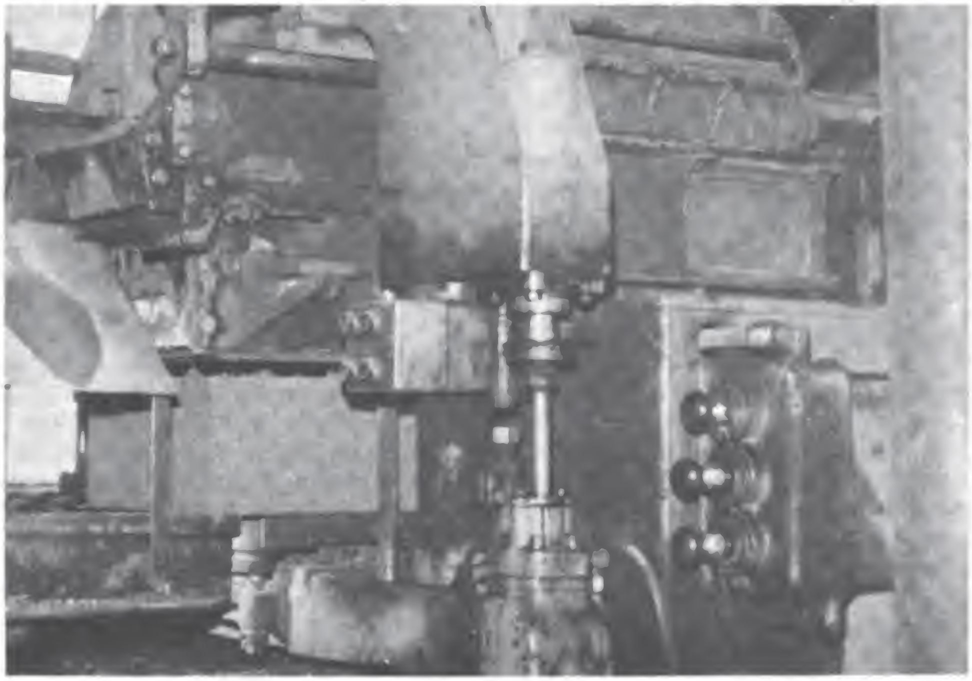
For a particular machine, the manufacturer's manual is the only satisfactory guide to the procedure for operating and caring for the machine. Figures 5-19 and 5-20 show the block-molding parts of a typical machine. Here mix is fed into the mold from an overhead hopper, after which a tamper strikes the mix a heavy blow. The mold is then raised clear of the green block (clear of more than one green block in a machine which molds more than one at a time.) The pallet on which the block(s) rest is then fed out onto a table, while another pallet if fed under the hopper. Pallets containing green blocks are stacked on a portable rack. When the rack is filled, it is moved to the curing area.

117.104
Figure 5-19.—Concrete block machine, showing finished block emerging.

BLOCK PLANT LAYOUT

The plant floor level should be not less than 6 in. above the general grade of the yard, to assure adequate drainage. In addition, concrete yard runways should be slightly above the grade of the surrounding yard, so that they will remain free of pebbles and other obstructions which might interfere with the operation of lift trucks and other equipment.

Adequate space should be allowed at the sides and in front of the block machine, so that lift trucks can be maneuvered with the maximum speed and ease. The general tendency in the layout of plants has been to economize on space in the immediate area of the block machine, on the theory that compactness produces effi-



117.105
Figure 5-20.—Concrete block machine, showing block directly below elevated form.

ciency. Though this theory is generally true when hand-lift trucks are used, the advantage disappears when power lift trucks are utilized. It is therefore well to err on the side of too much space adjacent to the machine. However, regardless of the general layout, aggregate and cement should be stored as near the mixer as possible.

The trend is toward the practice of elevating all raw materials into overhead bins, for gravity discharge from the mixer into the machine. For obvious reasons, if the raw materials are elevated at all, the elevation should be high enough to permit gravity flow. With such an arrangement the mixer is located on a separate floor level directly above the block machine.

CONCRETE BLOCK INGREDIENTS

Concrete block ingredients are the usual concrete ingredients: portland cement, water, fine aggregate, and coarse aggregate.

Cement

Type I or ordinary cement is used where the usual curing period of from 7 to 28 days doesn't require expediting, and Type III (high early strength) when the curing period requires shortening. Air-entrained cement produces the same advantage (resistance to freeze-and-thaw deterioration) in block as in other concrete. However, for block an air-entraining agent may be necessary to attain maximum consolidation and optimum results, especially when lightweight aggregate is used.

Aggregate

The aggregates used consist of sand, gravel, crushed stone, slag, cinders, or other inert materials or combinations of materials. They must be free from excessive amounts of dust, soft or flaky particles, or shale, and of organic and other deleterious materials. Where stationary aggregate bins are provided in a cold climate, a coil of steam pipes should be arranged around the outlet to thaw out frozen lumps. This heating of the aggregate also expedites hardening in cold weather.

As with ordinary concrete aggregate, the No. 4 screen is the line of demarcation between fine and coarse. Natural sand is the most widely used fine aggregate, although crushed granite,

limestone, traprock, marble, and cinders, as well as manufactured lightweight materials mentioned later, are used. Fine aggregate is usually suitably graded when all of it will pass the No. 4 sieve and at least 15 percent is retained on the No. 8. However, if from 10 to 20 percent passes the No. 50 as well, the density and texture of the block is improved.

Small amounts of silt or clay may not be objectionable, provided they contain no organic matter. Sand with not more than 10 percent of silt is usually safe for use in making concrete units.

The maximum size of coarse aggregate (material retained on the No. 4 screen) is limited by the smallest section dimension of the unit being made. The dimensions largest pieces should not exceed one-third of the smallest section dimension. In practice, for hollow building units this limits the maximum size of coarse particles to about 3/8 in.

Gravel is the coarse aggregate most frequently used. A uniform gradation from smallest to largest particles, similar to that for ordinary concrete aggregate of the same size range, is required. A tolerance of about 15 percent passing the No. 4 sieve is not objectionable.

Crushed stone is an excellent coarse aggregate, except that slate and shale are not recommended and some forms of sedimentary rock may be lacking in durability. Density is important; therefore, soft, easily abraded stone should be avoided. The stone should be free from dust; washed material should be used when possible. The tolerance is the same as that for gravel.

Blast furnace slag affords an economical source of coarse aggregate in the vicinity of furnaces and steel plants.

A lightweight aggregate is so-called because it weighs 100 lbs per cu ft or less (ordinary sand weighs about 110 lbs per cu ft). The commonest lightweight aggregates are expanded perlite and exfoliated vermiculite. Others are ordinary coal cinders, flyash, and expanded slag—meaning slag which is blown into a porous mass which is crushed and screened for lightweight aggregate.

Admixtures

There are a number of chemical admixtures which may be added to concrete to improve various qualities or to aid in the curing process. Fine-ground sand, hydrated lime, or a pure white clay called KAOLIN are added to increase workability and improve density. They also act as void fillers, thereby compensating for any possible deficiency of finer fines. Addition of these inert admixtures should be limited to from 3 to 8 percent of the weight of the cement.

Calcium chloride may be added to accelerate early strength. If used in flake form the amount varies from about one pound per sack of cement for high temperature (around 90° F) to four pounds per sack in the lower temperature ranges. In this dry form it is added to the aggregate rather than to the cement.

Calcium chloride in solution is added to the mixing water—the amount of mixing water should, of course, be reduced to allow for the water in the calcium chloride solution. A solution is made by dissolving 100 lbs of flake calcium chloride in 15 gals of water, and then diluting with an additional 10 gals of water. This makes a solution containing exactly 1 lb of calcium chloride per quart. Quantities added to mixing water per sack of cement used, for various temperature ranges, in terms of pounds of calcium chloride, are: above 90° F, 1 lb; from 80° F through 90° F, 1.5 lbs; from 32° F through 80° F, 2 lbs; below 32° F, 3 to 4 lbs. However, additions in excess of 2 lbs (meaning 2 quarts of solution) are risky, because they may cause "flash" settings which impair the strength of the concrete.

An air-entraining agent, either already present in an air-entrained cement or added as an admixture, tends to improve surface texture and reduce green breakage. Because of the nature of a block mix, best results are obtained by the use of a larger quantity of the agent than is contained in an air-entrained cement. The optimum quantity added is dependent on the type of aggregate, type of machine, and other factors; it is determined by trial and test. The addition of an air-entraining agent to a lightweight-aggregate mix has special advantages. A lightweight aggregate is inherently irregular in shape, which creates placing and finishing problems. The use of a quantity of air-entraining agent about twice that used for a mix with ordinary dense aggregate tends to plasticize the mortar, thus reducing particle segregation and improving placing and finishing.

CONCRETE BLOCK MIX DESIGN

Machine-made blocks must, if the forms are to be stripped at once for re-use, be made with a mix which is dry, or nearly dry, (that is, has a zero slump or less) at the time the forms are stripped. For a load-bearing concrete

building unit the compressive strength requirement seldom exceeds 800 psi. For a compressive strength of only 800 psi, you could in theory use 20 gals of water per sack of cement. Obviously this would produce an extremely soupy mix which could never be used machine-wise. Therefore, the conclusion is that any quantity of water you use per sack that will get a mix of reasonable consistency will be well within the maximum quantity prescribed for the desired compressive strength. This means that the W-C ratio, which is usually the basic factor in the design of an ordinary concrete mix, is more or less irrelevant in the design of a block mix. For a block mix, the ratio of cement to fine aggregate to coarse aggregate is the controlling factor. The water you add is enough water to ensure that (1) all aggregate particles are mortared, and (2) the mix will have a consistency which suits the particular machine. In practice this works out usually to a W-C ratio of about 5:1.

A typical block mix formula is 1 cement: 5.3 sand: 2.7 coarse, by volume. Because lightweight aggregate is often used in block, mix formulas are often given by volume rather than by weight.

The first thing to note about the given typical formula is that it follows a general rule to the effect that, in a block mix, the ratio of fine aggregate to coarse is about 2:1. This is roughly the reverse of the usual ratio of fine to coarse for an ordinary mix, indicating that here again the high ratio of fine to coarse is the chief factor in producing a "dry" mix.

These proportions presume a mix in which all the fine aggregate will pass the No. 4 sieve, and in which the maximum size of coarse is 3/8 in. In general, 3/8 in. is the largest coarse which can be used in hollow units.

The general rule of a ratio of 2 fine to 1 coarse is only a general starting point. The same applies to a second rough rule, to wit: that the proportion of cement to total amount of aggregate is about 1:8 by volume. Satisfactory proportions can be determined only by trial mix and test, the object being to determine the mix which will produce the maximum strength for a given expenditure of cement. Trial mixes containing fine to coarse ratios of 4:1 (25% coarse), 3:1 (33-1/3% coarse), 2.2:1 (45% coarse), and 1.8:1 (55% coarse) should be tried with ratios of cement to total aggregate of 1:6, 1:7, 1:8, 1:9, 1:10 and 1:11. All these proportions are by damp, loose volume.

In general, the coarser the grading of the aggregate, the greater the strength of the unit will be for a given cement content. However, the coarseness of the mix is limited by the extent to which fines are required for machine workability. It is at the machine itself that the first indication of suitable aggregate and cement combination becomes apparent. If the appearance of the surface and edges of a test block is satisfactory and if the units being produced can be handled easily without broken webs and corners, the mixture is approaching suitability.

Uniform grading (similar to that prescribed for ordinary concrete) is usually best for block. When units in trial batches break easily, the trouble is usually the fact that the fine aggregate is deficient in fines! A sieve analysis is then in order. If a deficiency of fines appears, the addition of small amounts of fine sandstone screening or other fine aggregate will aid in making the mix more workable (remember that here again workability means adaptability to machine-tamping or packing).

MIXING FOR BLOCK

As mentioned before, you can't in the nature of things add enough water to a block mix to weaken the concrete. The usual tendency has been to err on the opposite side, by not using enough water. Water should be added to the point where a freshly stripped unit will just stand up, with the surface showing occasion web-like water marks.

Experienced operators are usually able to test the mixture for water content by squeezing a handful of it. When traces of moisture show on the outside of a squeezed handful, the water content is usually about right.

The relatively dry mix used in a block machine requires longer mixing time than that required for an ordinary mix. The time must be long enough to ensure that every aggregate particle in the mix is mortared, and a high preponderancy of fine creates a much larger particle surface area than is the case with an ordinary mix of the same volume.

There is difference of opinion as to just what mixing time is necessary to achieve thorough coating of the particles. Some producers mix their materials for as long as 15 or 20 minutes, which requires, of course, additional expense for mixing capacity. More conservative authorities believe that mixing time beyond about 6 minutes is not economically justified.

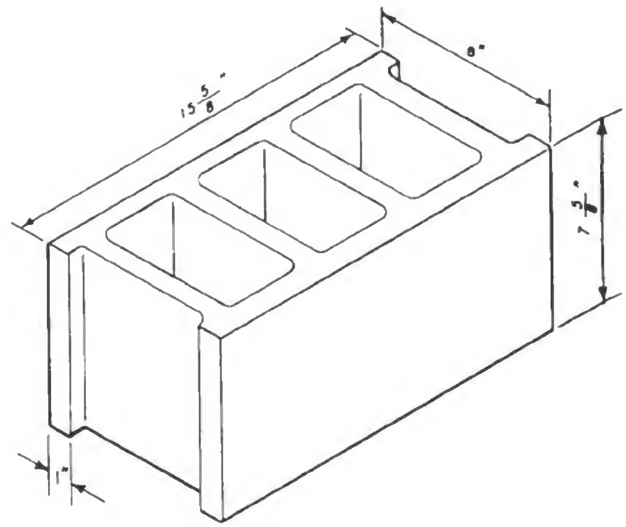
For a mix using ordinary dense aggregate (sand and gravel), the cement and aggregate should be mixed dry for about a minute before the water is added. With lightweight aggregate, the aggregate and about one-half to two-thirds of the water should be mixed together for 2 or 3 minutes before the cement is added. This practice is necessitated by the highly absorbent character of lightweight aggregate. Premixing as described fills the pores of the aggregate with water before the cement is added, thus preventing dry cement from getting into the pores where it would be ineffective. After the remainder of the water has been added, at least 6 minutes mixing time should be allowed.

QUANTITY ESTIMATING

You know how to determine the yield of concrete per every 1-sack batch of a given mix. Suppose that for your block mix this works out to 4.2 cu ft of concrete per 1-sack batch. How many 1-sack batches would you need to make (say) 800 units of the type shown in figure 5-21? This depends on the volume of concrete in each unit. For the unit shown in figure 5-21, the face shells and webs are 1 inch thick. The volume of concrete in each face shell is therefore 15-5/8 x 7-5/8 x 1, or 119 cu in. Therefore, the volume of concrete in the face shells is 2 x 119, or 238 cu in. The volume of concrete in each web is (8 - 2) x 7-5/8 x 1, or 45.7 cu in. The volume of concrete in the four webs is therefore 4 x 45.7, or 182.8 cu in. The total volume of concrete in the unit is 238 + 182.8, or 420.8 cu in. There are 1728 cu in. in a cu ft; therefore, the number of cu ft of concrete in each unit is 420.8/1728, or 0.244 cu ft. For 800 units, then, you will need 800 x 0.244, or 195.2 cu ft. If you get 4.2 cu ft from each 1-sack batch, the number of 1-sack batches you will need for 195.2 cu ft is 195.2/4.2, or about 46. Therefore, you will need 46 sacks of cement. From the number of sacks of cement and the mix formula, you can determine the quantities of fine and coarse aggregate you will need.

CURING CONCRETE BLOCK

Much breakage of concrete block during shipment and handling, and much inadequate service of block in walls and other structures, are results of inadequate or improper curing. To stress the importance of proper curing, we will briefly review the reasons why any concrete must be properly cured.



117.106
Figure 5-21.—One type of concrete block.

The reasons are all based on the fact that the hardening process is a CHEMICAL action (called HYDRATION) between the CEMENT and the WATER. The first consideration, then, is the fact that complete hydration cannot occur in the ABSENCE of the minimum amount of water necessary for complete hydration of the particular quantity of cement. Therefore, if the surface of freshly cast concrete is permitted immediately to dry out, the cement in the concrete near the surface will not be fully hydrated.

A second consideration is the fact that heat is required for complete hydration; in general, hydration stops almost completely when the temperature of the concrete drops below 40° F. It follows that concrete which freezes before hydration is completed is badly deteriorated.

Obviously, then, complete hydration depends on (1) keeping the unit moist during the curing period, and (2) maintaining the unit at a temperature above that at which hydration begins to be impaired during the curing period.

In a warm climate in which the temperature will not drop below about 60° F, blocks can be satisfactorily cured in the yard, provided that adequate cover (as of straw, tarpaulin, etc.) is used for each block to prevent evaporation of surface moisture. Yard-curing is usually impractical, however, because of the difficulty of providing adequate cover for large numbers of units, and because yard-curing requires a full 28-day interval. Consequently, block is usually

cured in a specially constructed curing room, in which both the prevention of moisture evaporation and the maintenance of satisfactory temperature are provided by the introduction of steam.

Construction of the Curing Room

A curing room should be sufficiently tight to prevent excessive rapid heat loss, and the door enclosures should fit as tightly as possible for the same reason. These enclosures may consist of hinged or vertical-sliding counterweighted doors, but canvas drop curtains are often used on curing-room doors which connect with the block-machine room. The ideal arrangement is one in which the curing room has no openings communicating with the outside, but only openings communicating with the block-machine room.

Side walls and partitions are usually built of 8 x 8 x 16 concrete masonry units. Lightweight units usually provide better heat insulation than units containing ordinary dense aggregate. The roof should consist of poured concrete slab, additionally insulated. A room is generally made wide enough to hold two racks side by side, with about 12 in. clearance between them, and overhead clearance of at least 12 in., more, of course, if lift trucks are to be used for stacking pallets. However, the ceiling should be as low as possible to keep the heat as low as possible, since there may be a temperature differential between floor and ceiling of as much as 50°.

The ceiling should be crowned or pitched, so that moisture from condensation will tend to run down to the side walls, rather than drip on the loaded racks. Inside wall surfaces and ceiling surface should be given a sealed coating if possible.

Low-Pressure Steam Curing

Most concrete block is cured at relatively low temperature (120° F or less) with low-pressure steam. There are various methods for introducing steam into the curing room and maintaining desirable temperature and humidity. Dry heat may be provided by 2-in. diameter RADIATION COILS extending the full length of the room on both sides. Or fog-heat may be provided by adding fog nozzles (attached to the ceiling) to the radiation coils. In still another system, steam, moisture, and radiation are combined by opening petcocks in the bottom return line of the radiation coil.

High-Temperature Steam Curing

Block can be steam-cured at 120° F in about 48 hours. HIGH-TEMPERATURE-STEAM curing reduces this interval to about 24 hours. The block is first moist-cured for about 12 hours, then dry-cured in an ordinary low-pressure room at a temperature of about 200° F. A circulating hot-air furnace is required to attain the required temperature, and the room should be arranged (by the installation of exhaust fans) so that moisture from the wet cycle can be quickly exhausted in preparation for the dry cycle.

High-Pressure-Steam Curing

Curing in as little as 9 or 10 hours can be accomplished by the use of high-pressure steam. Cylindrical steel AUTOCLAVES (steam-tight cylinders) are used for the purpose. The freshly made units are wheeled into the cylinders, the closures are made, and steam at 120 psi is introduced. Inside temperature rises to about 350° in about 3 hours. After 7 or 8 hours of curing the steam is turned off. It takes about 1/2 hour for the pressure inside the autoclave to subside to normal atmospheric pressure; the units are then removed.

TEXTURE

The two principal ways of varying the texture of the units are: (1) varying the grading of the aggregate used or the consistency of the mixture, and (2) the use of manual or mechanical means to give variety to the texture obtained by (1). The second is usually accomplished by the use of a fine water spray or by the use of wire or bristle brushes to texture the face of a unit immediately after molding.

When the texturing is done by spraying, care should be taken not to etch the surface too deeply or wash the cement out of the surface. It is recommended that, when texturing is to be done by this method, a richer mixture be used, and that the spraying be continued only just long enough to remove surface film so as to expose the aggregate.

Surface effects are also obtained by sprinkling coloring materials or ground mica on the face of the mold before molding.

Small check marks or cracks, usually in a web-like pattern, are known as "crazing." Crazing is caused by volume changes incident to variations of moisture and temperature during the setting period. A tendency to crazing is

difficult to eliminate entirely; however, the tendency can be lessened by the use of relatively lean mixtures (it is the active ingredients—the cement and water — that cause crazing), by thorough curing, and by avoiding the use of too much water.

CEMENT-PLASTER AND MORTAR MIX DESIGN

In construction operations, the Builder's job may often involve mixing of cement-plaster and mortar, as well as concrete. Already in this chapter we have discussed principles applicable to concrete mix design. In concluding this instruction, therefore, let us consider some of the principles involving cement-plaster and mortar mix design.

In preparing mortar mixes, the proportions to be used for the first and second coats should be one part by volume of portland cement to not less than three nor more than five parts by volume of damp, loose sand. Note that variations in sand requirements are brought about by differences in sand gradation throughout the country. Experience with sands from a particular source will help you to determine the proper mix. Until you acquire the necessary experience, trial mixes will be necessary.

An experienced Builder should be able to recognize a good mixed batch of cement-plaster by its workability, ease of troweling, adhesiveness to bases, and its non-sagging on vertical surfaces. Bear in mind that batch-to-batch uniformity in proportioning mixes will help ensure uniform suction and color.

The amount of hydrated lime used as a plasticizer should not exceed 10 percent by weight or 25 percent by volume of the portland cement. There are other good plasticizing agents such as asbestos fibers (shorts) or diatomaceous earth that can be used; the amount required will vary depending upon the agent used and the degree of plasticity desired. Determining the amount of workability desired in advance will aid you in deciding the kind and amount of plasticizing agent necessary.

Lime or other plasticizers must not be added when using masonry cement or plastic cement for cement-plaster mixes, because these cements already contain plasticizers. The mixture should be from three to five parts of sand and one part by volume of masonry cement or plastic cement. The use of these cements is an advantage in mixing because only sand and water need to be added.

Use of white portland cement and a fine-graded, light-colored sand will give the finish coat truer colors and a more pleasing appearance. The proportions should be as follows: one part by volume of white portland cement, up to 1/4 part by volume of hydrated lime, and between two and three parts by volume of sand plus the desired mineral oxide pigment. Weighing the color pigment for each batch will help ensure a uniform color batch to batch. The sand should all pass a No. 16 sieve. Make sure the sand is well graded from coarse to fine.

In some areas where two-coat work is applied over a masonry base, masonry cement often is used for both the base and finish coats.

It is important that materials for all coats be thoroughly mixed. Ensure that dry ingredients are mixed to a uniform color before any water is added. You will find a power mixer a useful device for uniform mixing and blending of materials. After all materials are in the mixer, they should be mixed for at least five minutes.

For satisfactory results in concrete masonry operations, it is important that mortar mixes be properly prepared and applied. Some factors to consider in regard to mortar mixes for concrete masonry are discussed below.

Good mortar, which is necessary to good workmanship and good wall service, must bond the masonry units into a strong, well-knit wall. The strength of the bond is affected by various factors including the type and quantity of the cementing material, the workability or plasticity of the mortar, the surface texture of the mortar bedding areas, the water retentivity of the mortar, and the quality of workmanship in laying the units.

Workability, an important requirement of mortar, should be obtained through the proper grading of the sand, and the use of mortar with good water retentivity, and through thorough mixing rather than through the use of excessive amounts of cementitious material.

Water retentivity is that property of mortar which resists rapid loss of water to masonry units which may possess high absorption. Loss of moisture due to poor water retention results in rapid loss of plasticity and may seriously reduce the effectiveness of the bond. As concrete masonry units should be kept dry until they are built into the wall, they should never

Proportions by Volume

Type of service	Cement	Hydrated lime	Mortar sand, in damp, loose condition
For ordinary service.	1—masonry cement*	-------------	2-1/4 to 3.
	or 1—portland cement.	1/2 to 1-1/4--	4-1/2 to 6.
Subject to extremely heavy loads, violent winds, earthquakes, or severe frost action. Isolated piers.	1—masonry cement* plus 1—portland cement	-------------	4-1/2 to 6.
	or 1—portland cement.	0 to 1/4------	2-1/4 to 3.

*ASTM Specification C91 Type II.

117.188
Figure 5-22.—Recommended mortar mixes.

be wetted to control suction before the application of mortar.

The strength and durability requirements of a mortar depend upon the type of service the wall is to give. Walls subjected to severe stresses or to severe weathering naturally need to be laid in more durable, stronger mortars than walls for ordinary service. The table in figure 5-22 lists mortar mixes that provide adequate mortar strength and durability for the conditions indicated. The volumetric proportions shown may be converted to weight proportions by multiplying the unit volumes by the weight per cubic foot of the materials, which may be assumed to be as follows:

Masonry cement—Weight printed on bag.
Portland cement—94 lb.
Hydrated lime—40 lb.
Mortar sand, damp and loose—85 lb. (approximately).

Bond is the property of a hardened mortar that knits the masonry units together. The strength of bond is affected by a number of factors such as the kind and quantity of cementitious material, the workability of the mortar, the surface texture of the mortar bedding areas, the rate of suction of the masonry units, and the quality of workmanship in making the joints.

CHAPTER 6

LOGGING OPERATIONS

As a BU1 or BUC, you must be able to supervise crews engaged in logging and sawmill operations. To do a good job, it will be advantageous for you to be thoroughly familiar with the different operations involved. In this chapter we are primarily concerned with logging operations; sawmill operations are covered in the following chapter. You will find that the chapter on foremanship (ch. 9 of this text) contains a lot of information that will apply to supervising crews performing logging operations, as well as crews doing other types of work within the Builder rating.

In this discussion attention is focused on the operations required in logging and the equipment and procedures used to accomplish these operations. As a supervisor, or logging foreman, you will find the information presented here especially useful as a guide toward ensuring that various logging operations are carried out properly and safely. We will discuss the duties of operating personnel and organization of crews. Information is given on felling, limbing, bucking, and scaling operations. We will also cover types of equipment and methods used in handling logs and moving them from the forest to the sawmill site.

You are aware, of course, that logging is not only hard work but also dangerous work. As a logging foreman, therefore, you may need to give closer supervision to crews performing logging operations than crews doing less hazardous work, especially if you have men who are inexperienced in logging work. In view of the importance of safety, special attention is given throughout this chapter to safety precautions applicable to various operations involving logging.

PERSONNEL REQUIREMENTS

For our purposes, LOGGING is defined as the process of converting standing timber into saw logs or timber products and delivering them to the sawmill for the manufacture of lumber or heavy timber. The process of logging is divided into two major divisions—felling the tree and preparing it for transportation, and transporting the prepared portions of the tree (saw logs) to the sawmill. These operations are performed by the logging and hauling section.

The entire logging and hauling section is composed of a logging crew and a hauling crew. Under the supervision of a logging foreman, each member of a crew may have several duties to perform during a normal logging operation. After the area to be logged has been selected, the logging foreman is responsible for the planning and construction of "woods roads" and loading platforms. The logging foreman is an expediter; it is his responsibility to see that sufficient logs of the correct size and type are delivered to the mill yard.

In addition to the logging and hauling crew, the logging foreman has supervision over the vehicle operators, the air compressor operator, the tractor operator, and the log scaler. A point to note is that while the Builder serving as logging foreman has overall supervision of the job, it is not likely that he will exercise direct supervision over men holding other ratings. These men will probably be under the direct supervision of a petty officer within their rating. An Equipment Operator, for instance, most likely will have direct supervision of the Equipment Operators engaged in logging operations.

The LUMBERJACKS in the logging crew are normally assigned to felling trees, sawing felled trees into logs (bucking), and loading logs for transport. However, when a new logging operation is started, the lumberjacks will aid in the construction of roads and loading docks in the woods. If necessary, they will construct log-handling and skidding devices. After the new area is prepared, they will resume their normal duties of felling, bucking, and loading.

The HAULING CREW is responsible for skidding the cut logs from the woods to the loading dock. In preparing an area for logging, the hauling section uses its equipment for road construction.

Logging calls for teamwork not only between the logging crews working in the timber, but also between the hauling crew and the sawmill crew. The logs must be prepared and delivered to the mill in such quantities that a large enough supply is on hand to keep the sawmill in operation. Logging requires the handling and movement of heavy loads. Since the logging crews are engaged in a hazardous operation, rigid safety rules must be established and complied with to prevent serious injuries to personnel and damage to equipment.

WOODS ROAD

The term "woods road" is used to designate any one of the three basic types of roads used in the logging operation; they are truck road, primary skid road, and secondary skid road. The selection of nomenclature for the three basic roads is arbitrary; however, the following nomenclature will identify them according to their use.

A TRUCK ROAD is a semipermanent, all weather road capable of handling heavily loaded log trucks moving from the log loading dock to the mill site.

The PRIMARY SKID ROAD is used to move logs by means of log-skidding vehicles from the cutting site to the log loading dock located adjacent to the truck road. The primary skid road usually is not more than a mile long. In the area being logged, the roads are usually located so that the trees to be cut are within 200 feet of the skid road. The primary road is constructed to withstand erosion and the movement of the loaded skidding vehicles.

The use of a SECONDARY SKID ROAD is not recommended unless absolutely necessary. The secondary skid road in most cases ties into the primary skid road system. Its use is limited to areas inaccessible to the normal skid road. This road may be typified by extremely steep grades, poor drainage, narrowness, and primitive construction. Generally, a secondary skid road is used once or twice and then abandoned.

FELLING

Felling is one of the most dangerous and difficult jobs in the logging operation. Trees are felled by chopping a notch in one side of the tree and then cutting from the other side with a chain saw or a crosscut saw. The skills required for felling cannot be attained by reading a few pages of text, but the information presented here may help Builders engaged in felling to avoid some of the more common mistakes.

FELLING CREW DUTIES

A feller equipped with a chain saw is responsible for felling, limbing, and bucking the tree. If the trees are not marked, he selects the tree to be cut. The feller may have an assistant equipped with an ax to increase operating efficiency and to promote greater safety. The assistant removes trash accumulated in cutting, and aids in lifting pieces for their proper cutting.

The crosscut saw crew is a two-man crew, the head feller and the second feller. The head feller carries the saw and one double-bit ax. If the trees have not been previously marked for cutting he selects the tree to be cut. He determines the direction of fall and the size of the undercut. After assuring himself that workers nearby have moved to safe positions, he directs the felling of the tree. Just before the tree falls he gives the warning signal "TIMBER". The second feller carries one double-bit ax, a sledge hammer, and wedges. He acts as assistant to the head feller. During bucking he is responsible for limbing the tree while the head feller is measuring the tree into log lengths.

LAYOUT OF FELLING JOB

The general layout of the felling job is highly important. As logging foreman, it will be your responsibility to decide on a layout that saves time and labor. Since felling (often called falling) is very dangerous work, make sure that you, as well as the fellers, are thoroughly familiar with all possible dangers that can be avoided by using the proper methods for felling the timber. Where conditions permit, much time and work can be saved by felling the trees so that the tops and branches can be left where they fall. On some operations where parallel roads are provided, all the trees are felled away from the road so that the tops are windrowed in the middle of the space between the

roads (A, fig. 6-1). On other jobs the tops of several trees are felled together in a "jackpot." Tops should never be dropped in a road or skid road if it can possibly be avoided.

It is important, particularly on jobs where the tree trunks are to be skidded out in long lengths, to fell the trees so that they can be removed most easily. This generally means felling them with butts toward the road at about a 45° angle. On some softwood jobs in dense stands of timber exactly the opposite course is followed. The trees are felled away from the remaining standing timber, with their tops toward the road (B, fig. 6-1). This reduces lodging (hanging up in an adjacent tree rather than falling tree to the ground). Also, a heavier load can be carried under the logging arch when the trees are hauled in top first.

Another method to be considered, especially when a tractor and logging arch are to be used for skidding, is to start the felling operation at the far end and top of the logging area and work toward the log landing. This prevents working over and through limbs and tops from previously felled and limbed trees.

DIRECTION OF FALL

Before starting to use the ax or saw on the tree, it is necessary to examine the tree and its location carefully and decide just where the tree should be dropped. The choice is usually limited by the layout of the operation and the location of the tree. Inexperienced fellers may take unnecessary chances of injury by starting the job too hastily. If the tree is leaning not more than 5°, has about the same amount and size of limbs all the way around, and is not being pushed by a strong breeze, the fellers can drop it in about any direction desired. This is done by the proper location of undercuts and use of wedges to tip it on the stump.

Big trees that lean noticeably or have heavy branches on one side can seldom be thrown in the opposite direction without the use of a block and tackle or other similar equipment, ordinarily not available in the woods. Most of the leaners, however, can be thrown 45° to the right or left of the direction in which they would naturally fall. It is up to the feller to decide just where in this arc his tree should be directed. It can be dangerous to fell a tree into another one. One reason is that the impact may change the direction of fall. Among other things, either tree may have limbs which may snap off and fall on the feller. These limbs are sometimes called "widow makers."

It is also unwise to fell a tree straight up a steep slope. The tree may bounce as it strikes the slope and kick back over the stump to

A. Felling along parallel roads. B. Felling with tops toward the road.
117.189
Figure 6-1.— Felling patterns.

strike the unsuspecting feller who thought he was away from danger. There is no way of telling what the tree will do. The best way is to fell the tree diagonally along the hillside and seek safety on the upper side of the stump away from the direction of the fall. Trees felled straight down a steep slope are likely to be shattered by the fall, particularly if the ground is rough. It is bad practice to let a tree fall across a large rock, stump, or another log as these tend to break the trunk and cause waste of much of the good timber. Another hazard to be considered in felling a tree is that it may become lodged in the branches of another tree, wasting time and causing trouble.

CLEARING WORKING SPACE

Once the direction of fall is determined, the next step is to clear away brush, saplings, and low-hanging branches that could interfere with the use of the ax or saw as the feller works at the base of the tree. Small brush is clipped off close to the ground by holding the ax in one hand near the point of balance and the brush in the other. Pulling on the brush provides the necessary resistance to a splicing cut (A, fig. 6-2). Larger brush and saplings (B, fig. 6-2) are also cut in this manner by bending the stem while making slanting downward cuts. Low hanging limbs are removed in the same way.

SAFETY IN BRUSHING OUT

In BRUSHING OUT, ensure that the general safety rules listed below are carefully observed.

Check the ax handle for cracks, splits, or splinters. See that the ax head is wedged tight, and that the blade is sharp.

Look over the ground around the tree for rocks, logs, or holes which might cause falls.

Check the tree for hanging branches that might fall on, or be in the way of, men felling the tree.

Wear a hard hat for protection against falling branches.

If carrying a saw, place it on the ground away from the working area before starting to brush. Do not set the saw where it can fall on personnel or where someone is likely to trip over it and get injured.

To prevent concentrations of flammable materials, scatter cut brush and saplings over a wide area.

Never embed a double bladed ax in a stump or tree. Lay it flat on the ground and in the open where it can be easily seen.

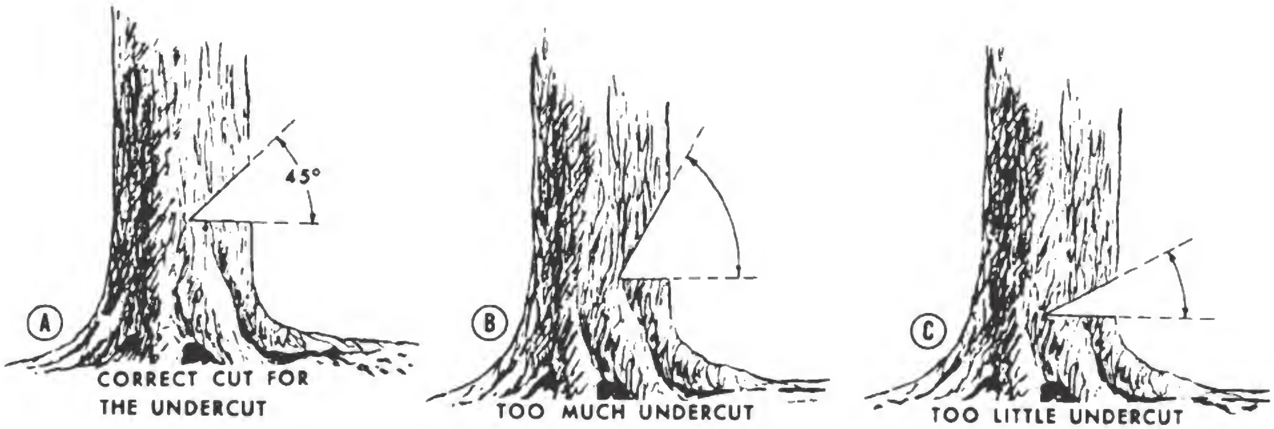
MAKING UNDERCUT

An undercut is made on the side toward which the tree is to fall. Its functions are to provide a fulcrum and hinge point on which to

A. Clearing away small brush. B. Clearing away saplings.

117.190

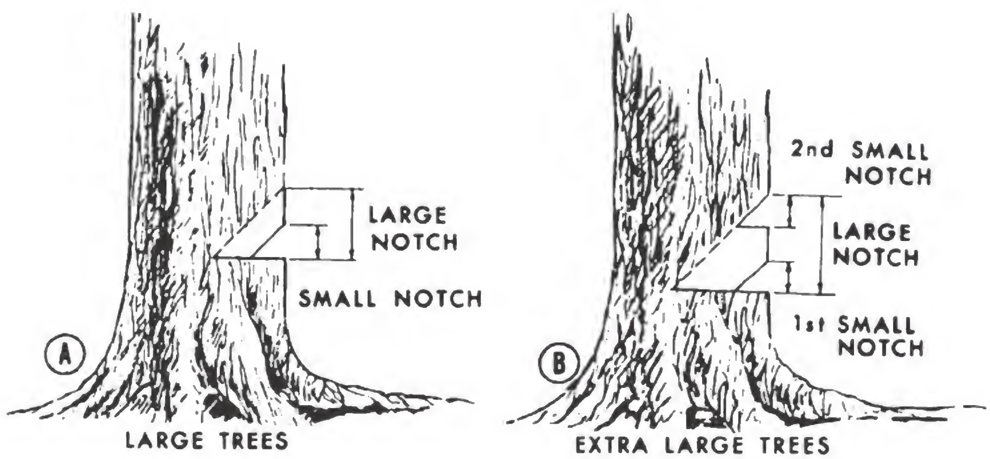
Figure 6-2.—Clearing.



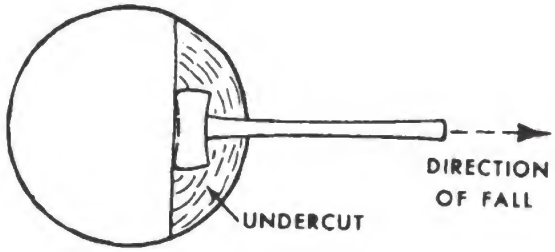
117.191
Figure 6-3.—How to make the undercut.

tip the tree off its stump. The stump should be not more than 12 inches above the ground level on the upper side of the tree. High stumps waste timber and hinder skidding. Exception to the 12-inch rule must be made, of course, when a rock or some other obstruction makes a low stump impossible. If a chain saw is used, the entire undercut is made with the saw. If a crosscut saw is used a horizontal cut is made to a depth of about one-fourth of the diameter of the tree and the notch is chopped out. The usual practice is to chop the notch above the saw cut on a 45° angle, as shown in view A, figure 6-3. A larger notch, like that indicated in view B of the same illustration, requires unnecessary chopping; and a smaller notch, as shown in view C, is too hard to make.

An inexperienced chopper will have trouble in getting the chips to fall out properly. The best method of chopping is to bury only part of the ax edge in the wood at each stroke. If the heel or the nose of the ax is exposed, the chip tends to roll off easily. This can be done by working first the center, then both sides, and repeating the process in that order. In large trees, it is necessary to cut a small notch first and then chip down the full sized notch, as indicated in figure 6-4. In extra large trees it may be best to make too small notches and one large notch, as also indicated in figure



117.192
Figure 6-4.—Notching a large tree and an extra large tree.



117.193
Figure 6-5. — Use of double-bit ax in testing direction of fall.

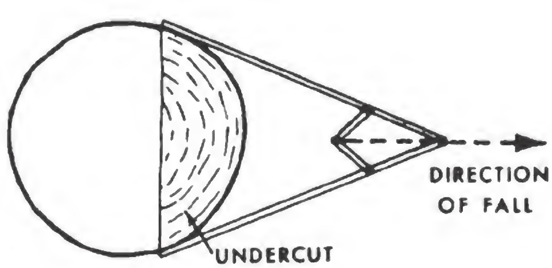
6-4. This prevents binding, thus making the chipping-out easier.

TESTING DIRECTION OF FALL

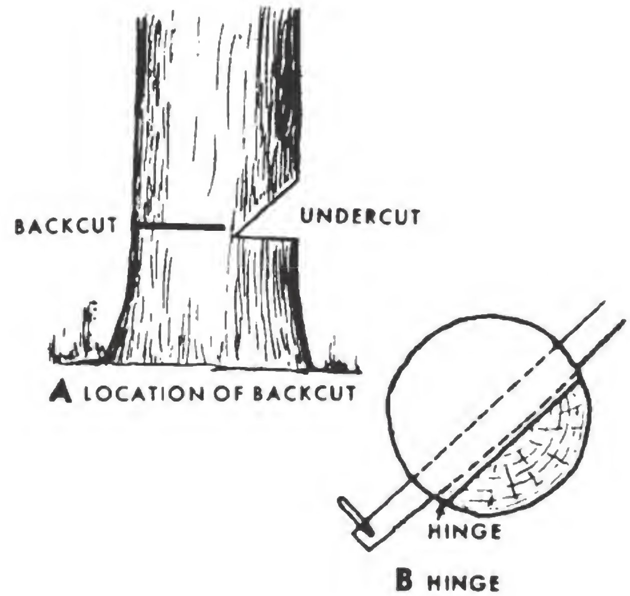
When the undercut is completed, it is well to check the direction of fall. One simple test is to push the head of a double-bit ax into the crotch made by the undercut, as illustrated in figure 6-5. The handle should then point in the direction in which the tree is to fall. Another method of determining the direction of fall is to use a gun stick, as indicated in figure 6-6. The two points are placed one at each edge of the undercut. The apex then points in the direction of fall.

MAKING BACKCUT

The backcut (A, fig. 6-7) should be approximately 2 inches higher than the bottom of the undercut. The cut normally should be kept parallel with the undercut until only 2 or 3 inches of holding wood is left. If the tree has not fallen by this time, it should be tipped by driving in



117.194
Figure 6-6. — Use of gun stick in testing direction of fall.



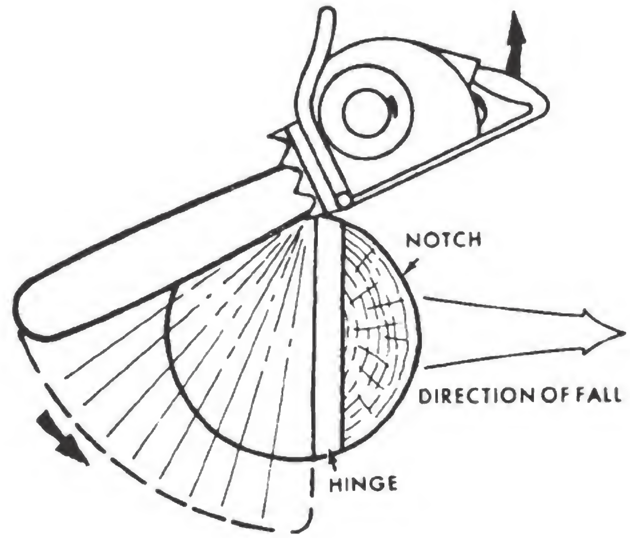
117.195
Figure 6-7. — How to make the backcut and hinge.

one or two felling wedges behind the saw. As the sawing is continued, the wedges are driven enough to keep the tree tilted. Do not saw to less than 1 inch of holding wood. This is needed to serve as a hinge (B, fig. 6-7) that will guide the tree as it falls. When a two-man crosscut saw is used to make the backcut, each sawyer should keep his partner informed of how near the saw is to the undercut so one side will not be too far ahead of the other.

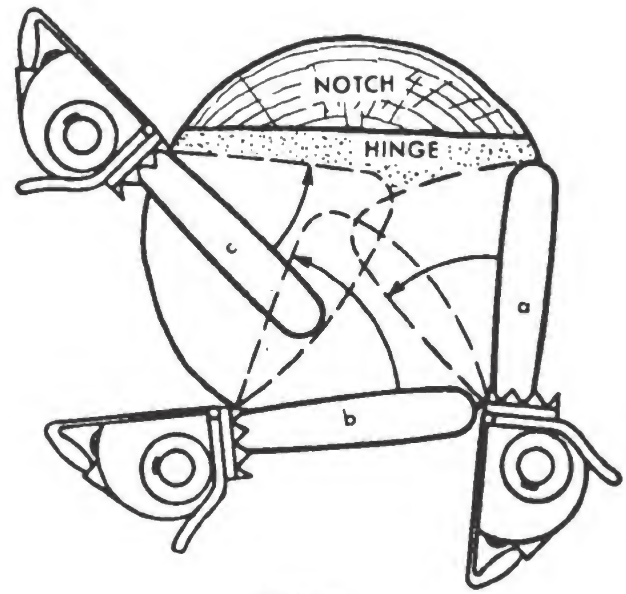
Before starting to saw a tree, each man should plan his getaway path. The tree should be observed closely for any rotten or dead limbs that would be likely to fall when the tree is chopped or wedged. Some trees, especially if they have rot in them, fall quickly. It should be decided who will remove the saw. The feller should quickly move back to one side of his sawing position (preferably behind another tree) and carefully watch the tree as it falls.

FELLING WITH A CHAIN SAW

The backcut made with a chain saw is similar to that made with a crosscut saw. The difference is the speed and flexibility of operation. Extra care must be taken to prevent cutting through the hinge. (See fig. 6-8.) While sawing, watch for widening of the cut and glance at the top of the tree for indications of motion preceding



117.196
Figure 6-8. — Normal felling cut.



117.197
Figure 6-9. — Felling cut, large diameter.

the fall. Withdraw the saw from the cut as soon as the tree is leaning sufficiently to assure a complete fall.

Trees with a larger diameter than the length of the chain saw guide bar can be felled by consecutive cuts after the undercut has been made (see fig. 6-9). It is very important that the first of the felling cuts be positioned approximately 2 inches above the floor of the undercut, and that each of the other two cuts follow in the same plane. The use of wooden wedges is helpful in assuring that the cut will open.

A safe rule to follow is: If the cut cannot be made with a crosscut saw, it cannot be made with a chain saw. That is, if the tree or log will "bind" with a crosscut saw, it will "bind" with a chain saw.

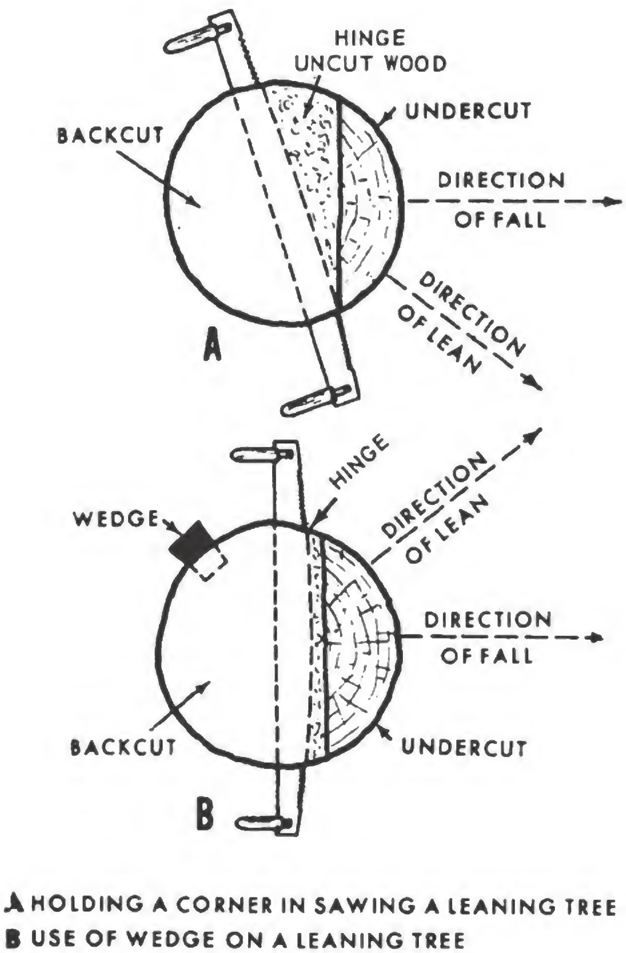
LEANING TREES

When a tree leans slightly in a direction different from the one in which it should be dropped, the direction of fall can be changed to a certain extent by "holding a corner." This is done in the backcut by simply leaving more wood on the side opposite the one toward which it leans (A, fig. 6-10). This acts as a holdback to twist the tree away from the direction in which it leans.

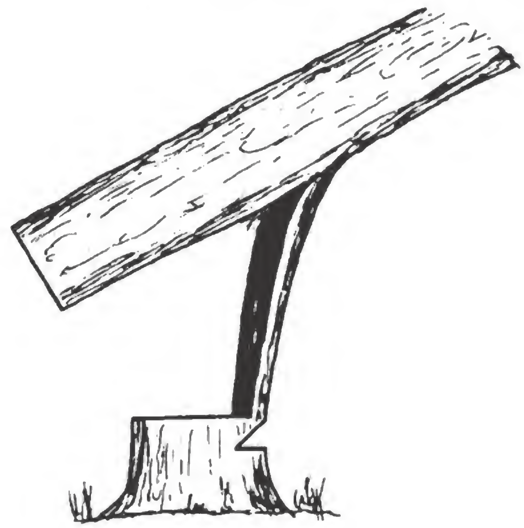
Wedging can also be used to alter the direction of a fall. One or more felling wedges are driven into the backcut on the leaning side (B, fig. 6-10) to tip the tree into an upright position from which it can be made to fall in the desired direction.

A gusty wind can sometimes be used to help fell a tree in the direction desired. If the wind is blowing exactly in the desired direction, the fellers merely adjust their rate of sawing so that the last few inches of wood are cut when the breeze is steady enough to take the tree over. If the wind is coming from the opposite direction the problem is much more difficult. The cutters will have to time their work so that their sawing is finished exactly at the time when the wind has died down and the tree is swaying back from the force of the gust. On some days when the wind is changeable, felling may become so dangerous that it should be discontinued altogether. Small trees, of course, can be pushed over in almost any direction by hand.

Trees leaning in the direction of fall can be dangerous. They usually fall sooner than ex-



117.198
Figure 6-10.—Felling a leaning tree.

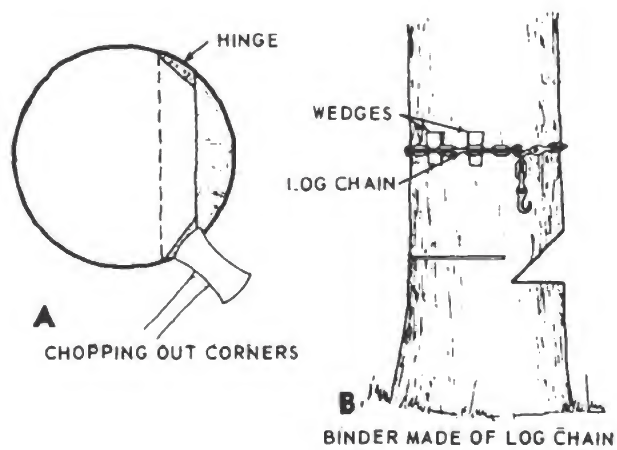


117.199
Figure 6-11.—A "barber-chair" stump.

pected, splintering the butt, and thrashing around in unpredictable directions. One common result is the "barber-chair" stump (fig. 6-11), in which the most valued part of the tree is spoiled. One method that will usually prevent a leaning tree from splitting in this way is called "sawing off the corners." The backcut is halted before there is any danger that the tree will fall. Then, each corner is sawed off at an angle. The same result can be obtained by chopping out the corners of the undercut (A, fig. 6-12). Another method used to reduce splitting of large bad leaners or hollow-butted trees is to fasten a log chain around the base of the tree just above the backcut (B, fig. 6-12). Wedges driven between the chain and the tree will tighten the chain and prevent serious splitting.

Some valuable leaning trees that can be dropped only in the direction of the lean can be cut three-fourths through from the leaning side by using wedges to prevent pinching the saw. The saw is then removed, and the cut completed from the backcut side. A good general rule to remember is: THE GREATER THE LEAN, THE DEEPER THE UNDERCUT.

It is possible to fell trees 2 feet in diameter and greater in the opposite direction of lean, if required, providing the lean is not too great.



117.200
Figure 6-12.—Methods used to prevent splitting of tree.

In this operation the backcut is made first on the side of the lean, so that wedges can be applied before the saw is pinched. Sawing and wedging is continued until the tree is in true vertical position after which the undercut is made. After making the undercut, the backcut is completed and wedges are applied until the tree falls.

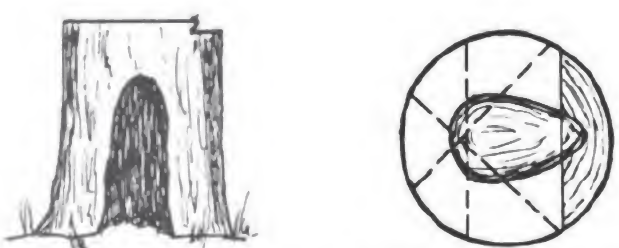
ROTTEN TREES

Rotten-butted trees present a difficult felling job. Extra precautions will have to be taken to try and anticipate the time and direction of their fall. A large percentage of the most serious accidents occurs in attempting to bring down rotten-butted trees. If possible, the felling cuts are made high enough to avoid most of the rot (A, fig. 6-13). This not only results in safer felling, but also saves the time spent sawing the rotten portion from the butt log. When the rot goes up too high for this, it may be possible to chop or saw around the rot with cornering cuts (B, fig. 6-13) similar to those used for leaning trees.

When the butt of the tree is badly decayed, it is much safer to chop it down and not use the saw at all. The feller should be more alert than usual when felling a rotten tree. The direction in which it falls is very difficult to control.

HANDLING LODGED TREES

Even the most experienced tree feller sometimes lodges a cut tree in a standing one. An exceptionally sturdy limb on either the tree being felled or the one in its way may fail to bend as expected; or the cut tree may fall or twist out of line. The better and more experienced the felling crew, the fewer trees the crew will lodge. Dislodging may be easy and safe, or it may be very difficult and dangerous, depending on conditions. Cutters must be able to diagnose how firmly a tree is lodged and what method of getting it down is best.



A STUMP CUT HIGH TO AVOID ROT

B SAWING AROUND ROT

117.201

Figure 6-13. — Felling rotten trees.

If the tree is lightly lodged, cutting it loose from its stump and prying the butt off to the ground may cause the tree to dislodge and fall. Pushing or twisting it loose is the next step, and is frequently used when only the ends of the limbs are caught. Climbing up the inclined trunk of the lodged tree and attempting to shake it loose by jumping up and down is a dangerous procedure, and is NOT recommended even for the most experienced men.

The safest and most practical way to free a lodged tree is to back the logging tractor to within a safe distance from the tree, attach a winch cable around the butt of the lodged tree, and pull the tree down.

WARNING Perhaps the most dangerous practice of all is to cut the tree in which the first one is lodged. In doing this, it is difficult to judge the stresses involved, or the way the two trees will fall. If this method becomes necessary, the most experienced and alert man should do the chopping alone, because he will be in a better position for a getaway than a saw crew. Also, working alone, one man can better judge when and in what direction to run.

SAFETY IN FELLING

All personnel performing felling operations should keep safety uppermost in mind. Some of the major safety precautions that should be carefully observed are listed below.

Before making any cuts in the tree, study it carefully for lean, obstructions to the path of fall, wind effect, rolling effect of trunk colliding with adjacent obstacles during its fall, and center of gravity of the tree.

Choose a safe line of retreat from the tree and remove all obstacles which could block the way.

Wear some kind of reinforced head gear—if possible, a safety helmet which will protect your head from falling limbs or other objects.

Two men should not chop together on a tree of less than 20 inches in diameter.

Do not leave a tree which has been started, even at lunch time or at the end of a shift.

Before starting to make the cut, get steady footing to be sure your feet will not slip.

Do not attempt to start a chain saw by holding it in the hand and pulling the starter with the other hand. Place the saw on solid footing and secure it well before attempting to start.

The chain saw's engine and accessories reach high temperatures during operation. Be careful not to touch hot parts. Gloves are a help in case of accidental contact.

Do not check the tension of the chain with the engine running, even though the chain is not moving.

When crews are working several saws together, they should keep a reasonable distance apart so that warning shouts can be heard.

Do not move the saw from one tree to another while it is running.

Watch the fall of the tree to be on guard against limbs of other trees being snapped back.

FIRE PREVENTION RULES FOR POWER SAWS

In working with power saws, see that the following fire prevention rules are strictly adhered to:

Do not smoke while filling gasoline tanks. Use a gasoline can with a spout or use a funnel. Fill the tank only on an area of bare ground.

Do not start the engine at the place the tank was filled.

Keep the entire saw clean of gasoline, oil, and sawdust.

Be sure the muffler is in good condition. Keep the muffler in place at all times while the saw is in operation.

Keep the spark plugs and wire connections tight.

Clear flammable material away from the point of saw cut.

Promptly extinguish any fires. Report fires and possible causes of fires immediately to the proper authority.

LIMBING, BUCKING, AND SCALING

This phase of our discussion deals with operations involving the limbing, bucking, and scaling of logs. Procedures that may be used in carrying out these operations are described in the following sections.

LIMBING

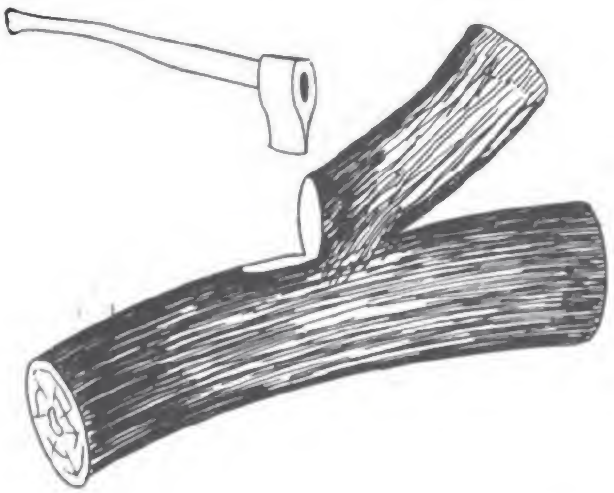
After the tree is on the ground, the next step is the removal of the limbs. This operation is known as LIMBING and is usually done with the ax or chain saw. When using the ax, the limbs should be cut from the lower side, cutting from the base toward the top of the tree. The stub of the limb should be left even with the tree bark. Trees that have been carelessly limbed are hard to skid and load.

Limbing is like other chopping in most ways. The same grip on the handle and the same swing are used. Much of it does, however, have to be performed in restricted areas and from awkward positions. The variation in size of limbs calls for good judgment as to the right amount of force to be put behind the swing of the ax. There is a much greater chance of accident from an ax swung amidst branches than from an ax used in clear chopping, so the axman should clear away any branches that are likely to interfere with chopping. Where possible, the axman should cut limbs on the opposite side of the log (see fig. 6-14) and swing the ax away from himself. The inexperienced chopper should not do any limbing while standing on the tree trunk. As he gains experience and learns control of his ax, he will be able to work safely in positions hazardous for the inexperienced.

For large limbs, particularly on hardwoods, it is often necessary to cut a notch similar to

117.202

Figure 6-14. — Cut limbs on the opposite side of the log, where possible.



117.203
Figure 6-15.—Cutting off a large limb.

that used in cutting down a tree (fig. 6-15). The limb is cut from the lower side and the bottom surface is kept even with the trunk surface. The vertical side of the notch should slope somewhat with the angle of the limb. Often a large notch is easier to cut than a small one. The downward cut is made at a slant with the grain of the wood and not directly across it. Thus chopping should be done slightly at an angle to the grain, and there should be no attempt to twist out the chips. Larger limbs on hardwoods are usually easier to saw off than to chop off.

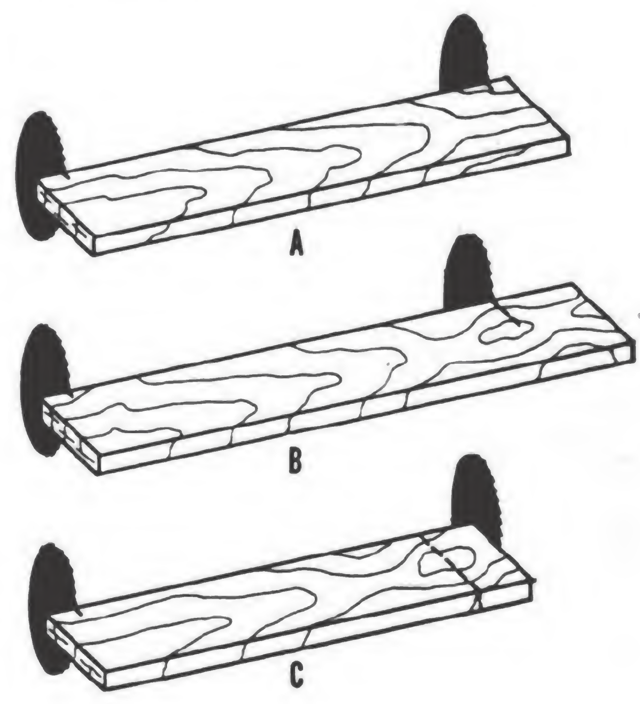
BUCKING

As logging operations have become more mechanized, the bucking operation (cutting the tree into log lengths) has been shifting from the stump location to the loading dock, or even to the mill where the wood is utilized. There is economy in handling long logs or tree length timber when the quantity to be handled justifies the use of heavy equipment for skidding, loading, and hauling. There is another advantage in bucking at the landing or in the mill yard. Semiportable power saws become feasible; logs can be cut to more accurate lengths. A bucking crew that does nothing else will develop maximum skill in cutting the quality logs, especially out of hardwood trees.

Log Grades

Wherever the logs are bucked, the leader of the bucking crew must be familiar with the log grading system used for the species being cut. All grading systems are based on the grade of lumber that can be sawed from the logs. Logs suitable for sawing must meet the minimum standards of length, diameter, quality, and species. For practical purposes in bucking felled trees, the lead bucker should set up a grade of standards similar to that shown in table 6-1. For timber that is to be used for piling or other uses requiring long lengths, a separate table may be necessary.

The United States maintains the highest grading standards of any nation. In overseas operations it may be necessary to adjust grade standards to the standards which are in use in the area being logged. This will be particularly true if the timber is being purchased from private interests.



A. Right length allows just enough for trimming.
B. Extra length causes waste in trimming.
C. Too short for trimming, will be cut to next shorter standard length.

117.204
Figure 6-16.—Proper log lengths.

117.225
Table 6-1. — Typical Log Grading System.

Log grade	Small end diameter	Requirements	Description
No. 1 (good).......	Over 10".....	All lumber cut from this log must be No. 1 Common or better.	Surface and ends clear of defect, and sapwood bright in color. Two small limb knots are allowed, but two large knots on body knots make it a No. 2 grade. If the knots occur at each end it is a cull log.
No. 2 (common)....	Min 6".......	Two-thirds of the lumber cut from this log must be No. 1 Common or better.	Must not have more than three standard defects (note), or be only slightly wormy.
No. 3 (cull)........	....	One-half of the lumber cut from this log must be No. 2 Common with a little of the better grades.	More than two limb or body knots. Some worm and knot defects.

NOTE. (1) Standard defects are—knots, rot, shakes, season checks, frost cracks, sun, scald, fire scars, seams, wormholes, stain, spiral or crooked grain, cat faces, and crook in the log. Most exterior checking and shallow cat faces are not defects, since they go into the slab only.
(2) No. 1 Common—⅔ of the surface of the board is clear faced.
(3) No. 2 Common—⅓ of the surface of the board is clear faced.

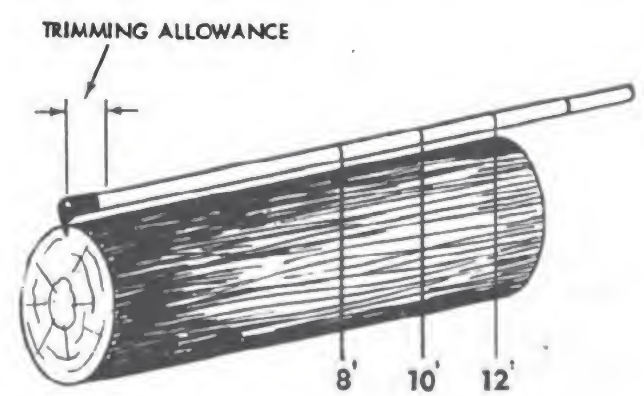
Log Lengths

Sawlogs are ordinarily cut in lengths from 8 to 16 feet by 2-foot intervals. Increasingly, as materials become more scarce, the demand is greater for the highest quality logs in the 8- to 16-foot group. However, where special types of construction are being undertaken, specifications frequently call for 20-, 24-, and even 32-foot material. Therefore, good judgment in dividing the tree into logs and a knowledge of the specification requirements cannot be overemphasized. Accuracy is also important. Ordinarily, a 3-inch trimming allowance for each 16-foot or shorter length is specified in order that any irregularity in the ends can be evened off by the trim saws at the mill (A, fig. 6-16), leaving square-end boards of the full specified length. Logs with a greater allowance are penalty scaled for unnecessary wastage (B, fig. 6-16). Logs failing to have this allowance are scaled in the next lower allowable length (C, fig. 6-16).

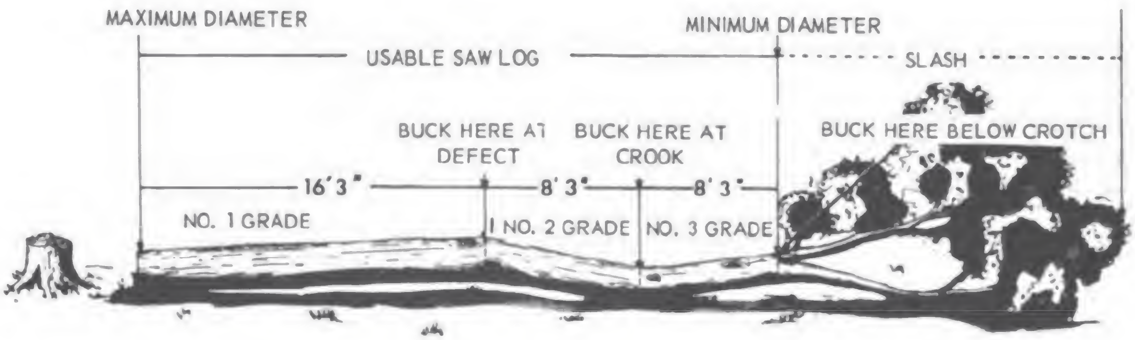
An accurate log measuring pole (fig. 6-17) showing the specified trimming allowance at the butt should be used. A metal hook on the butt end of the pole is often an aid to its more accurate use.

Bucking Procedures

The first step in bucking sawlogs is to measure the total usable length of the tree (fig. 6-18). This total should be subdivided into the individual log lengths in a way that will obtain both maximum scale and grade. This is done before the crew starts to buck. The following suggestions will aid in obtaining maximum scale and grade.



117.205
Figure 6-17. — A log measuring pole.



117.206
Figure 6-18.—Log bucking plan.

Saw cuts made below large limbs generally give larger scale in the butt log, since the knots are not included.

Wherever possible, surface defects should be kept in the butt portions of logs, where they will be trimmed off in slabs.

Defects should be grouped in one log if possible. This often means sawing knots, rotten areas, and so on, which is contrary to the natural inclination of the sawyers, but it raises the grade of the product.

Sawing too close to the base of a crotch and showing a double heart on the small end of the log should be avoided.

If practicable, cuts should be made at points of the most abrupt crook, leaving the cut logs as straight as possible.

Wedges should be used frequently in bucking to prevent pinching the saw. The crew will ordinarily carry two or three wedges and a maul to drive them.

Before starting to buck, all brush or trash on either side of the log should be cleaned out to get space to work.

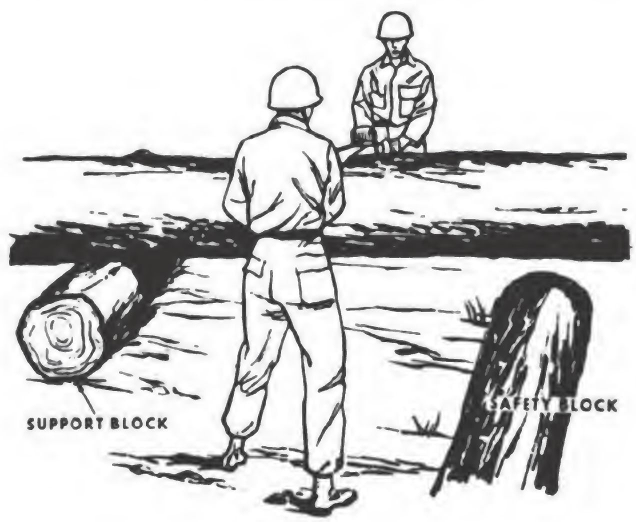
Because of the weight of the logs, blocks (fig. 6-19) should be placed alongside the trunk to keep the cutoff section from dropping or rolling on one of the buckers, especially when working on a hillside or sloping ground.

Blocking used under the trunk prevents the log from splitting with a consequent loss of valuable material.

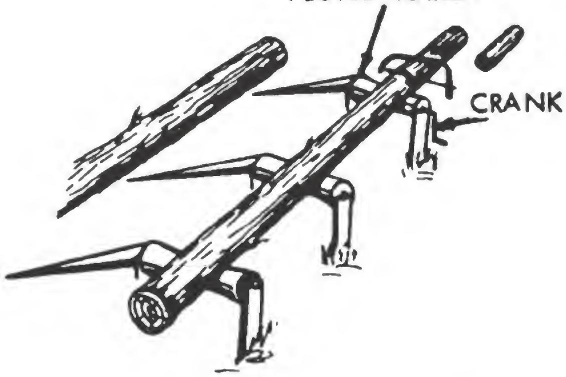
Sometimes, when a heavy trunk is suspended from the two ends, it is necessary to make part of the cut from underneath. This is a more difficult operation because either the power saw or crosscut saw will have to be held into the cut.

Use of Mechanical Equipment

When the tractor and logging arch are being used to haul tree lengths to the log yard, and the bucking is being done at the landing, larger crews can be used to good advantage. The work can be more closely supervised and greater use of mechanical equipment for bucking is feasible. Bucking skids and chutes are sometimes constructed to ease the handling of logs and to avoid the possibility of pinching. Bucking is done on the end of the log which is unsupported. A mechanical bucking chute (fig. 6-20), either hand- or motor-operated, offers several ad-



117.207
Figure 6-19.—Method of propping and bucking a log.



117.208
Figure 6-20. — Mechanical bucking chute.

vantages. A series of concave rollers with the front roller fluted or spiked can be used. The front roller is usually hand-crank operated to advance the log for each succeeding cut. The advantage is that the log beyond the saw is unsupported and, therefore, will not pinch the saw. Some mills bring the tree-length logs to the yard for bucking and also construct a motorized bucking plant. These mills are fabricated almost entirely at the site and use circular saws. Some saws are pushed or pulled into the log by a hand lever; others are swung into the log mechanically. If necessary, a large portion of the equipment in this mechanical method can be assembled from spare parts and various excess equipment available.

Log Classifying

The most important function of the Seabee log scaler will be that of classifying uncut logs. By judging the quality of the log, the scaler will determine its eventual use and mark it for bucking accordingly. If the timber is purchased by the log, his job will include measuring the logs for board- or cubic-foot content. Some of the more common uses and specifications for timber are listed below.

BOLTS are short portions of logs. BILLETS are obtained by halving, quartering, or otherwise splitting bolts or short logs lengthwise. Bolts and billets are used for many purposes such as cooperage, crating, pulp, and so on.

POLE specifications vary greatly. Specifications for poles generally require the material to be of the best quality, of specified dimensions, the butt to be cut square, reasonably straight, well portioned from top to butt, peeled, and with knots trimmed close. Defects looked for in inspection are crookedness, split tops, split butts, sap and butt rot, checks, and shakes. (Defects will be discussed in detail later in this chapter.)

The classification and grading of PILING depends largely upon its use, whether in fresh water or salt water or on land, and upon its form and size. Very often the kind of wood is not specified, and the requirements refer to straightness, length, and butt diameter measurement 3 feet from the end. Important construction work often calls for specifications similar to the following: All piling shall be cut from sound, live trees of slow growth and firm grain and free from ring heart, wind shakes, decay, large or unsound knots, or any other defects that will impair its strength or durability. The trees shall taper uniformly from butt to tip. Piles shall be so straight that the line joining the centers of the ends will fall entirely within the pile and that, in the opinion of the inspector, they can be subjected to hard driving without injury. No short or reverse bends will be allowed. Bark shall be peeled from the entire length of all piles, and all knots shall be trimmed close. No pile will be accepted with a top measuring less than 6 inches in diameter. The allowable diameter shall be as follows: Butts of piles under 30 feet in length to be from 12 to 16 inches and butts of piles from 30 to 50 feet in length to be from 12 to 18 inches.

The specifications for RAILROAD TIES in most cases are for sound timber of good quality, stripped of bark and free from imperfections, such as shakes and loose or decayed knots, that would impair their strength and durability. The ties must be sawed or hewed smooth on two parallel faces, and ends must be cut square. Pole ties are made of round timber on which are hewed two parallel faces; square ties are hewed or sawed inot rectangular shape. Ties are classified according to the species of wood, their wearing into and lasting qualities and their need for preservation treatment, and the thickness and width of face, or dimensions.

Any kind of wood measured by the cord and in the form of either round or split sticks is called CORDWOOD. Firewood is measured in standard cords, mostly 4-foot lengths, or short cords of stove wood and other material varying from 12 to 20 inches in length. Wood which is to be used for distillation, extract wood, excelsior, pulp wood, handles, cooperage, and woodenware is frequently sold by the rick or cord. The

lengths vary mostly from a minimum of 22 inches for heading and from 5 feet for extract and handle stock. Specifications, if given, refer to the kind of wood, length, average size of the pieces, whether split or round, general soundness, body or limb wood, and degree of dryness.

LOG SCALING

Log lengths can be conveniently measured by the log scaler with a measuring stick 8 feet long. About 3 inches should be added to the nominal length of the log, so that rough ends can be trimmed at the mill. If more than 6 inches of extra length is left, however, carelessness in sawing the trees into logs is indicated. For scaling purposes, the average diameter inside the bark at the small end of the log is measured. Several diameters may be measured where necessary to obtain a fair average. Diameters are rounded off to the nearest inch; that is, 7-1/4 would be considered 7, 7-3/4 would be considered 8, and 7-1/2 should be roughly divided equally between the 7-inch and 8-inch diameters.

As soon as each log is scaled it should be marked, so there will be no danger of scaling it again. If systematic scaling is done, it is desirable to use a special book for this purpose. Each log is recorded in the book with a cross or other mark. When the log is scaled its number is written on the small end of the log.

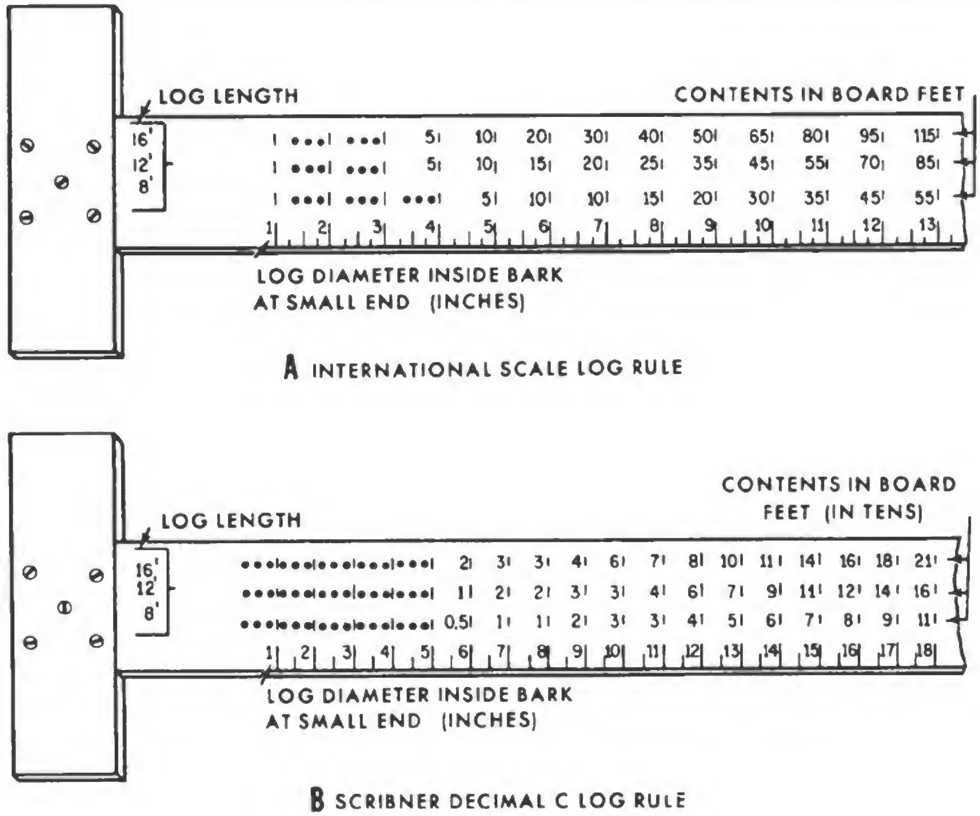
A sample form for a log scale book is illustrated in figure 6-21. Note that the book has been ruled off into groups of four columns: the first column for the number of the log, the second for its length (in feet), the third for its diameter (in inches), and the fourth for the scale (in board feet). Only one grade of timber should be entered on a page.

A log rule is used by the log scaler to determine the number of board feet in a log. Two types of log rules are illustrated in figure 6-22; they are the International scale log rule and the Scribner decimal C log rule. The scale stick is 48 inches long and calibrated to show

LOG NO.	LENGTH	DIAMETER	SCALE	LOG NO.	LENGTH	DIAMETER	SCALE
	FEET	INCHES	BD FT		FEET	INCHES	BD. FT.
1				12			
2				13			
3				14			
4				15			
5				16			
6				17			
7				18			
8				19			
9				20			
10				21			
11				22			

117.209

Figure 6-21.—Sample form for a log scale book.



117.210
Figure 6-22. — Examples of log rules.

the board-foot contents of logs up to 48 inches in diameter.

Scaling Logs in Board Feet
by Scribner Decimal C Rule

Scaling is subject to many small differences in practice in different regions with different organizations. The most practical scale is the Scribner decimal C log rule shown in table 6-2.

The maximum and minimum scaling lengths are usually set for each timber cutting operation. Logs longer than the minimum scaling length are scaled in 2-foot increments. Instead of taking the nearest 2 feet, the logs are scaled to the nearest even 2 feet below the actual length. A trimming allowance of 3 inches (for cutting the log off square at the mill and cutting off ends broomed or filled with grit in skidding) is allowed over scaling length. Too large a trimming allowance is corrected by scaling the log as the next longest 2 feet. Ordinarily, all logs over 16 feet are scaled as two or more logs of as nearly the same length as practical. Nominal lengths of either 16 feet or 12 feet are preferable when dividing a long log for scaling.

The length of the log is measured with a tape. The average diameter of the log inside bark at the small end is measured in inches with a scale stick or a ruler (B, fig. 6-22). The scale stick shows diameter in inches on one edge and on the other edge shows the board foot volume, in tens, by the Scribner decimal C rule, for that diameter of different lengths. Except where the small end of the log is perfectly round, the diameter inside bark is measured the longest and the shortest way, and the average diameter to the nearest inch is used. Thus, if the diameter inside bark at the small end is 18.5 inches the long way and 16 inches the short way, the average is 17.2 inches and the log would be called a 17-inch log.

For inexperienced scalers, the best rule is to assume even taper on all except butt logs.

117.226

Table 6-2.—Board Feet Content By the Scribner Decimal C Log Rule.

Diameter (inches)	Length (feet)											Diameter (inches)
	6	7	8	9	10	11	12	13	14	15	16	
	Contents (bd ft) in tens											
6	0.5	0.5	0.5	0.5	1	1	1	1	1	1	2	6
7	0.5	1	1	1	1	2	2	2	2	2	3	7
8	1	1	1	1	2	2	2	2	2	2	3	8
9	1	2	2	2	3	3	3	3	3	3	4	9
10	2	2	3	3	3	3	3	4	4	5	6	10
11	2	2	3	3	4	4	4	5	5	6	7	11
12	3	3	4	4	5	5	6	6	7	7	8	12
13	4	4	5	5	6	7	7	8	8	9	10	13
14	4	5	6	6	7	8	9	9	10	11	11	14
15	5	6	7	8	9	10	11	12	12	13	14	15
16	6	7	8	9	10	11	12	13	14	15	16	16
17	7	8	9	10	12	13	14	15	16	17	18	17
18	8	9	11	12	13	15	16	17	19	20	21	18
19	9	10	12	13	15	16	18	19	21	22	24	19
20	11	12	14	16	17	19	21	23	24	26	28	20
21	12	13	15	17	19	21	23	25	27	28	30	21
22	13	15	17	19	21	23	25	27	29	31	33	22
23	14	16	19	21	23	26	28	31	33	35	38	23
24	15	18	21	23	25	28	30	33	35	38	40	24
25	17	20	23	26	29	31	34	37	40	43	46	25
26	19	22	25	28	31	34	37	41	44	47	50	26
27	21	24	27	31	34	38	41	44	48	51	55	27
28	22	25	29	33	36	40	44	47	51	54	58	28
29	23	27	31	35	38	42	46	49	53	57	61	29
30	25	29	33	37	41	45	49	53	57	62	66	30
31	27	31	36	40	44	49	53	58	62	67	71	31
32	28	32	37	41	46	51	55	60	64	69	74	32
33	29	34	39	44	49	54	59	64	69	73	78	33
34	30	35	40	45	50	55	60	65	70	75	80	34
35	33	38	44	49	55	60	66	71	77	82	88	35
36	35	40	46	52	58	63	69	75	81	86	92	36
37	39	45	51	58	64	71	77	84	90	96	103	37
38	40	47	54	60	67	73	80	87	93	100	107	38
39	42	49	56	63	70	77	84	91	98	105	112	39
40	45	53	60	68	75	83	90	98	105	113	120	40
41	48	56	64	72	79	87	95	103	111	119	127	41
42	50	59	67	76	84	92	101	109	117	126	134	42
43	52	61	70	79	87	96	105	113	122	131	140	43
44	56	65	74	83	93	102	111	120	129	139	148	44
45	57	66	76	85	95	104	114	123	133	143	152	45
46	59	69	79	89	99	109	119	129	139	149	159	46
47	62	72	83	93	104	114	124	134	145	155	166	47
48	65	76	86	97	108	119	130	140	151	162	173	48
49	67	79	90	101	112	124	135	146	157	168	180	49
50	70	82	94	105	117	129	140	152	164	175	187	50

Thus, a log 40 feet in length, 16 inches in diameter at the small end, and 21 inches in diameter at the large end might be scaled as—a 16-inch log, 12 feet long, a 17-inch log, 12 feet long, and a 19-inch log, 16 feet long. This was figures as follows: total taper in 40 feet equals 21 - 16 = 5 inches; if the log has even taper this amounts to 1/2 inch per 4 feet; the top diameter of the first 12-foot length is the top diameter of the log or 16 inches; the top diameter of the next 12-foot log is the same as the butt diameter of the top 12-foot length of 16 plus 3 x 1/2 = 16 plus 1-1/2, or 17-1/2 inches, rounded off to 17 inches; the top diameter of the 16-foot length is the same as the butt diameter of the preceding 12-foot length or 17-1/2 plus 3 x 1/2 = 19 inches. For butt logs, inexperienced scalers should use taper tables. In some operations, odd-length lumber can be used. Under these conditions, logs will be scaled to the nearest whole foot in length below the actual length rather than to the nearest even foot.

Deductions for Defect Board Feet,
Using Scribner C Rule

The Scribner C rule is measured from the diameter of the small end of the log inside bark and allows for boards 1 inch thick with a saw kerf (width of cut made by a saw) of 1/4 inch between boards. No allowance is made for taper, and in the tables a certain amount of solid wood around the edges is allowed for slabbing (removing the outer surface of a log in order to obtain a flat surface for sawing lumber). In allowing for defects, therefore, any part of the defect falling in the slabs already deducted by the rule, or in the saw kerf already deducted by the rule, should not be deducted again in scaling. When the defect is in the center of the log, the deduction is reduced by the amount of saw kerf only; when the defect comes in from the surface of the log, the deduction is reduced by the amount of taper and slabs, as well as by the amount of saw kerf.

The Scribner rule treats the log as a RIGHT CYLINDER whose diameter is equal to the average diameter inside bark at the small end of the log, and whose length is the scaled length of the log. A right cylinder is a cylinder whose ends are perpendicular to the length. All defects outside the right cylinder of the log are disregarded, since no wood outside the right cylinder has been included in the gross scale of the log as given by the rule. In addition, a certain amount of slabbing has been omitted from the gross scale by the rule. The amount varies with the size of the log, but in allowing for defect it is assumed that it is equivalent to a collar 1 inch thick just inside the edge of the right cylinder. This is illustrated in views I and K, figure 6-23.

The STANDARD RULE for allowing for defects within the right cylinder and within the inside edge of the slab collar is:

$$\text{deduction} = \frac{a \times b \times L,}{15}$$

in which $\underline{a}$ is the depth or thickness of the defect, in inches; $\underline{b}$ is the width of the defect, in inches; and $\underline{L}$ is the length of the defect, in feet. This deduction is in board feet and must be divided by 10 to obtain tens of board feet corresponding to values given by the Scribner decimal C log rule. It will be noted that the divisor in the rule is 15 instead of 12. This reduces by 20 percent the amount already deducted in the rule for saw kerf. In the case of circular defects in the center of a log, a and b are equal and become D^2 in the formula for deduction. It is customary to add an inch to the actual thickness and width of the defect to allow for sawing around it. The standard rule might be written—for circular defects, taking out a square piece,

$$\text{DEDUCTION} = \frac{(D + 1)^2 \times L}{\qquad};$$

for defects taking out a rectangular piece,

$$\text{deduction} = \frac{(a + 1)\ (b + 1)L}{15}$$

in which $\underline{D}$ is the actual average diameter of the circular defect in inches; $\underline{a}$ is the actual thickness of the rectangular defect in inches; $\underline{b}$ is the actual average width of the defect in inches; and $\underline{L}$ is the length of the defect in feet.

The amount of defect in a log necessary to cause its rejection as a CULL LOG (a log that is economically usable in size but rejected because of defects) varies in different localities and usually is specified for each timber cutting operation. In general, logs of a valuable species in which less than 33 percent of the gross scale (read from scale stick or log table) is economically usable are considered cull logs, whereas logs of less valuable species in which less than 50

percent of the gross scale is economically usable are considered cull logs. Incidentally, logs of the valuable species are the finer cabinet woods such as walnut and cherry.

Common Defects

There are various types of defects for which deductions must be allowed in scaling logs. Figure 6-23 illustrates some of the common defects of concern to the log scaler. Methods used in making deductions of specific types of defects in logs are discussed below.

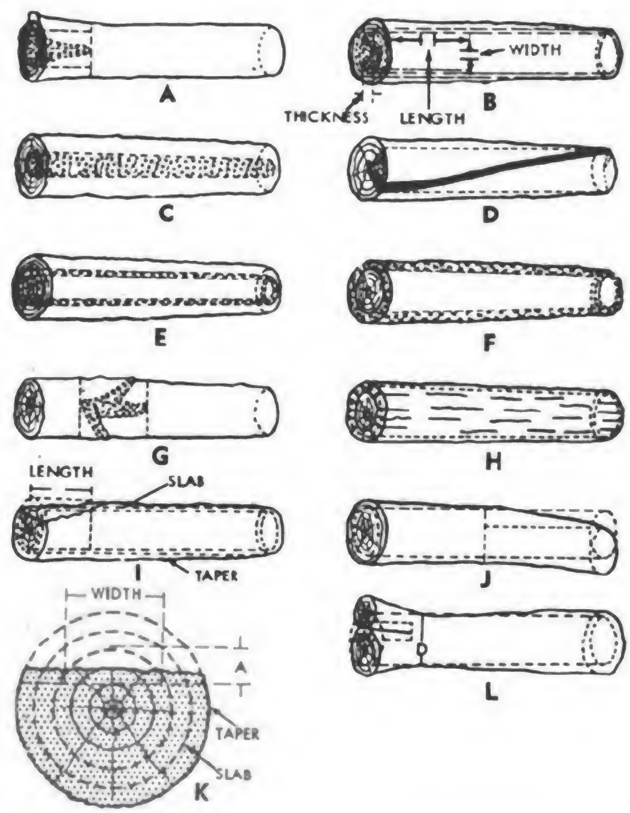
STUMP ROT.—Stump rot is found only in butt logs and is illustrated in view A, figure 6-23. Assume that the log illustrated is 12 inches in diameter inside bark at the small end and 16 feet long, and has stump rot with an average diameter of 8 inches at the butt end and estimated to extend 4 feet up the log. By the standard rule the deduction would be—

$$\frac{(8 + 1)^2 \times 4}{15} = 22 \text{ board feet,}$$

or rounded off to the nearest ten, 2.

The gross scale of a 12-inch, 16-foot log is 8 (from table 6-2). The net scale would be 8 - 2 = 6, or 60 board feet. Another method of deducting for stump rot is to reduce the length of the log by the length of the rot. In this instance, the net scale might have been found by looking up the volume of a 12-inch, 12-foot log (16 - 4 = 12). The rule shows 6, or 60 board feet, for such a log. The customary practice is to use whichever method will give the smaller deduction. In this instance it made no difference. Had the average diameter of the rot been 9 inches instead of 8 inches, the deduction by the standard rule would have been 26 board feet, or 3, giving a net scale of only 5, or 50 board feet. In that case, the log would have been scaled as a 12-inch, 12-foot log and the net scale would be 60 board feet as before. On the other hand, if the average diameter of the rot had been 6 inches instead of 8 inches, the deduction by the standard rule would have been 13 board feet, or 1, giving a net scale of 7 or 70 board feet. Under such conditions the standard rule would be used in scaling.

CIRCULAR ROT.—Circular rot may appear at only one or at both ends of the log. If it appears at only one end of the log, the diameter is taken at that end and the length it extends up



A. Stump rot
B. Heart check
C. Circular rot
D. Frost check
E. Ring shake
F. Punky sapwood
G. Rotten knots
H. Wind checks
I. Fire scar
J. Crook
K. Fire scar
L. Crotch

117.211
Figure 6-23.—Defects in logs.

the log is estimated. The deduction is made exactly the same as that for stump rot, unless it is estimated that the rot extends so far up the log, the remaining sound length is below the minimum length of merchantable board. In this case, the length of the log is used as the length of the rot. Ordinarily, this minimum length of board is 6 feet, but in some sections 6-foot boards are not economically usable.

A log with a circular heart rot showing at both ends is illustrated in view C, figure 6-23. Assume that the log is 12 inches in diameter inside bark at the small end and is 16 feet long. Its gross scale is 8, or 80 board feet. The defect is 4 inches in diameter at the small end and 6 inches in diameter at the large end.

For logs 16 feet in length, or shorter, the diameter of the rot is measured at the large end. By the standard rule the deduction is—

$$\frac{(6 + 1)^2 \times 16}{15} = 52 \text{ board feet,}$$

or rounded off to the nearest ten, 5. The net scale would be: 8 - 5 = 3, or 30 board feet. If cull logs are all those whose net scale is less than 50 percent of the gross scale, this log would be cull. If cull logs are those whose net scale is less than 33 percent of the gross scale, this log would be acceptable.

Suppose you are in a region where logs longer than 16 feet are scaled as one log and that the length of the log in view C, figure 6-23 is 18 feet and all other dimensions are the same. In this case the average of the diameters of the defect at the two ends would be used instead of the diameter at the large end. The average diameter of the defect at the two ends would be the average of 6 and 4, or 5 inches. The deduction by the standard rule would be—

$$\frac{(5 + 1)^2 \times 18}{15} = 43 \text{ board feet,}$$

or rounded off to the nearest ten, 4. The gross scale of a 12-inch, 18-foot log is 9, or 90 board feet. The net scale of the log would be: 9 - 4 = 5, or 50 board feet. The log would be more than 50 percent sound and would, therefore, be acceptable.

Now, suppose you are in a locality where logs longer than 16 feet are scaled as two or more logs and that the length of the log in view C, figure 6-23 is 18 feet. In this case, it would be scaled as a 10-foot log and an 8-foot log and taper would be allowed for in the defect as well as in the log. The diameter inside bark at the small end of the log is 12 inches and the diameter inside bark at the large end is 16 inches. The total taper is: 16 - 12 = 4 inches for the 18-foot length; this amounts to 0.22 inches per foot or 1.8 inches in 8 feet. The diameter inside bark at the top of the first 8-foot length would have been the diameter of the log, or 12 inches; the diameter inside bark of the 10-foot length would be 12 + 1.8 = 13.8, or 14 inches. The diameter of the defect at the small end is 4 inches and at the large end, 6 inches; the taper in the defect is 2 inches in 18 feet or 0.11 inches per foot or 0.88 inch in 8 feet. The diameter of the defect at the large end of the first 8-foot length would be 4 + 0.9 = 4.9 or 5 inches; the diameter of the defect at the large end of the 10-foot length is the same as the diameter of the defect at the large end of the log or 6 inches. Applied to the 8-foot length, the standard rule gives a deduction of—

$$\frac{(5 + 1)^2 \times 8}{15} = 19 \text{ board feet,}$$

or rounded off to the nearest ten, 2.

The gross scale of a 12-inch, 8-foot log is 4, or 40 board feet. The net scale of the 8-foot length would be 4 - 2 = 2, or 20 board feet. Applied to the 10-foot length, the standard rule gives a deduction of—

$$\frac{(6 + 1)^2 \times 10}{15} = 33 \text{ board feet,}$$

or rounded off to the nearest ten, 3.

The gross scale of a 14-inch, 10-foot log is 7, or 70 board feet. The net scale of the 10-foot length would be: 7 - 3 = 4, or 40 board feet. The net scale of the whole log would be: 2 + 4 = 6, or 60 board feet. The log would be acceptable.

RING SHAKE. — Ring shake is the separation of the layers of wood along the annual rings. This defect is illustrated in view E, figure 6-23. Ring shake may run only part of the length of the log or it may appear at both ends. It is treated exactly in the same way as a circular rot and deductions are made by the standard rule. Sometimes; however, there is a core of sound wood in the center of the shake which is large enough to be scaled as a merchantable log. In this case, the amount of deduction by the standard rule is reduced by the scale of this core. Assume that the log is 12 inches in diameter inside bark at the small end, 16 inches in diameter inside bark at the large end, and 16 feet long. Let us further assume that the shake is 7 inches in diameter at the small end, 8 inches in diameter at the large end, and extends the full length of the log; also, there is a solid core in the center of the

shake 6 inches in diameter at the small end of the log. The deduction by the standard rule is—

$$\frac{(8 + 1)^2 \times 16}{15} = 86 \text{ board feet,}$$

or rounded off to the nearest ten, 9.

The scale of a 6-inch, 16-foot log is 2, or 20 board feet. The net deduction for defect would then be: 9 - 2 = 7. The gross scale of a 12-inch, 16-foot log is 8, or 80 board feet. The net scale of the log is: 8 - 7 = 1, or 10 board feet. In this particular case the volume of the core is the true net volume of the log since the deduction by the standard rule is greater than the gross scale of the core. This log, however, would still be cull.

PITCH RING.—A pitch ring (not illustrated) is a heavy deposit of pitch along an annual ring or group of annual rings. This condition is treated in the same way as shake if the deposit is heavy enough to be a defect.

ROTTEN KNOTS.—Two or more rotten knots on opposite sides of the log and within an area of 2 linear feet are sufficient evidence that there is a limited amount of rot in the log even though the rot does not appear at either end of the log. The best background the scaler can have when allowing for such a defect is a knowledge of how different species of logs in the region showing this evidence of rot saw out in the mill. Where such knowledge is lacking, it is safe to assume that the rot runs down the stem to a point at least 1 foot below the lowest rotten knot and up the log to a point at least 1 foot above the highest rotten knot. This type of defect is illustrated in view G, figure 6-23. Suppose that the log shown is 12 inches in diameter inside bark at the small end and 16 feet long, and with a rotten knot 7 feet from the large end. The deduction is made by reducing the scale by the estimated length of the affected section. Allowing 1 foot below the lowest knot, the rot is estimated to extend within 3 feet of the large end. Allowing 1 foot above the highest knot, the rot is estimated to extend 8 feet from the large end or 8 feet from the small end. Since boards less than 6 feet in length are not economically usable, the sound wood below the rot cannot be included in the net scale. The length of the log must be reduced by 8 feet, therefore, the net scale of the log will be the scale of a 12-inch, 8-foot long log, which is 4, or 40 board feet. The gross scale of a 12-inch, 16-foot log is 8, or 80 board feet; hence, the log is acceptable.

HEART CHECK.—Heart check, illustrated in view B, figure 6-23, is deducted as a rectangle by the standard rule. Of course, if the log has spiral grain and the heart check is thereby twisted in the log, the size of the rectangle must be proportionately larger. This general principle is illustrated in connection with frost check in view D, figure 6-23. When the heart check appears at only one end of the log, the distance it extends into the log must be estimated. In applying the standard rule to heart check, a, the thickness of the rectangle, and b, the width of the rectangle, must be entirely within the right cylinder and the slab. It will be noticed in view B that the part of the heart check extending beyond the right cylinder and slab at the top of the log is disregarded in determining the dimensions of the rectangle, a and b.

Assume that the log shown in view B, figure 6-23 is 12 inches in diameter inside bark at the small end. Assume, too, that the heart check at the large end is 3 inches thick and 9 inches wide within the right cylinder and slab, and is estimated to extend 7 feet up the log. The deduction by the standard rule is—

$$\frac{3 \times 9 \times 7}{15} = 13 \text{ board feet,}$$

or rounded off to the nearest ten, 1.

The gross scale of a 12-inch, 16-foot log is 8, or 80 board feet. The net scale of the log is: 8 - 1 = 7, or 70 board feet. In regions where off-length boards are unmerchantable, the length of the defect would have been taken as 8 feet and the deduction would have been 14 board feet, or rounded off to the nearest ten, 1. The net scale would have been 7, or 70 board feet.

These defects are illustrated in figure 6-23.

FIRE SCAR.—The fire scar type of defect, caused by fire damage to the tree, is illustrated in the log shown in views I and K, figure 6-23. The common method of allowing for this defect is to divide the log in sections and estimate the proportion of loss in the section affected. The diameter inside bark at the small end of the log in view I is 12 inches; the length of the log is 16 feet; the depth of the fire scar at the large end is 6 inches and it extends up the

log for a distance of 5 feet. Within the right cylinder and slab, the length of the scar is only 4 feet and the depth of the scar is 3 inches (taper 4 inches in diameter or 2 inches in radius, slab 1 inch in radius; depth of scar 6 - 2 - 1 = 3 inches). The log is divided into 4-foot sections (length of scar inside right cylinder and slab) and the scale volume of each 12-inch, 4-foot section is 2, or 20 board feet. It is estimated that this scar takes up between 1/4 and 1/2 of the total volume of the 4-foot section affected. Assuming 1/3 of the volume of the section is lost in sawing around the defect, the deduction would be 1/3 of 20 or 7 board feet, or rounded off to the nearest ten, 1. The gross scale of a 12-inch, 16-foot log is 8, or 80 board feet. The net scale of the log is 8 - 1 = 7, or 70 board feet.

The deduction for fire scar may also be made by the standard rule. In the log shown in views I and K, suppose that L, the length of the scar within the right cylinder and the slab, is 4 feet; a, the depth of the scar within the right cylinder, is 3 inches (6 inches minus 2 inches for radial taper and 1 inch for slabs); and b, the average width of board lost, is 7 inches. The deduction by the standard rule is—

$$\frac{3 \times 7 \times 4}{15} = 6 \text{ board feet,}$$

or rounded off to the nearest ten, 1.

The net scale of the log is: 8 - 1 = 7, or 70 board feet, the same as that obtained by the usual method. It will be noticed from view K that sufficient depth was added in determining a to allow for sawing straight boards inside the fire scar and b was merely the average width of board lost. Wormholes, usually occurring on only one side of the log, may be deducted in the same way as a fire scar.

FROST CHECK. — Frost check is a separation of the wood along the tissue which separates the annual rings, or layers. It follows the grain of the wood. If the grain of the wood is straight, the loss from frost check is comparatively small, but if the log is spiral grained, as in view D, figure 6-23, the loss is considerably greater. The defective part is deducted as a piece whose base is a sector of the cross section of the log. Assume that the log shown in view D is 12-inches at the small end and 16-feet long, and that the affected wood takes up 12 inches of the 50 inches circumference at the large end, or approximately 1/4 of 8 = 2. The net scale of the log would be 8 - 2 = 6, or 60 board feet.

If the frost check enters the log only part way, just the affected part of the sector is deducted. Suppose that the frost check in the log of view D, figure 6-23, had penetrated only 2 inches into the log. The solid core inside the log would have a diameter of 12 - (2 x 2) inches = 12 - 4 = 8 inches inside bark at the small end. The scale of an 8-inch, 16-foot log is 3. The volume of a collar 2 inches thick is, therefore, 8 (scale of 12-in., 16-foot log) minus 3 (scale of 8-in., 16-foot log) equals 5, or 50 board feet. Only 1/4 of this was affected; hence, the deduction is 1/4 of 50, or 12-1/2 board feet, or rounded off to the nearest ten, 1. The net scale of the log would be: 8 - 1 = 7, or 70 board feet. If the check had spiraled all the way around the tree, the net scale would be the scale of a log inside the check, or 30 board feet.

Where the check extends only part way up the log, the deduction is first made on the basis of a short section including the length of the check. The deduction is then subtracted from the gross volume of the whole log. Lightning scars are treated in the same way as frost checks in scaling.

PUNKY SAPWOOD. — Deduction for punky or broken-down sapwood is made by reducing the diameter inside bark at the small end of the log by twice the radial depth of the defect. A log containing this defect is shown in view F, figure 6-23. Suppose that the log illustrated is 12 inches in diameter inside bark at the small end and 16 feet long, with a gross scale of 8, or 80 board feet. In addition, suppose the sapwood is defective for a depth of 2 inches all around the log. The log is scaled as an 8-inch (12 - 2 x 2 = 8), 16-foot log, having a scale of 3, or 30 board feet. If cull logs are all those whose net scale is less than 50 percent of the gross scale, this log would be cull.

WIND CHECKS. — Deduction for wind checks is made by reducing the small end diameter as for punky sapwood, except that only one-half of the average radial length of check is used as the radial depth of defect. This is due to the fact that the loss from this type of defect is not nearly so great further in the log as it is at the surface. A log with wind checks is illustrated in view H, figure 6-23. Let us assume that the log in view H is 12 inches in diameter inside bark at the small end, is 16 feet long, has a

gross scale of 8, or 80 board feet, and has wind checks all around the log entering the log to an average depth of 2 inches. Half the average length of check is 1 inch. The log is scaled as a 10-inch (12 - 2 x 1 = 10), 16-foot log, having a scale of 6, or 60 board feet.

CROOK.—In making deductions for crook or sweep, all the crook or sweep is thrown into the small end of the log and deduction is made from this top half. A right cylinder is drawn with a diameter equal to the small end of the log, but with a length parallel to the lower half of the log. Deductions are made for the part of this right cylinder falling outside the log. A log with a crook is shown in view J, figure 6-23. We will assume that the log in view J has a diameter at the small end of 12 inches and a length of 16 feet. We will also assume that the outside edge of the right cylinder falls 4 inches outside of the outer edge of the log at the small end. It appears that approximately 1/3 of the upper half of the log is affected by the crook. Some 10- and 12-inch boards can be cut in this affected third, but it appears that about 2/3 of this affected portion will be lost. The gross volume of a 12-inch, 16-foot log is 8, or 80 board feet. The upper half includes 1/2 of 80, or 40 board feet. The affected 1/3 of this upper half contains 1/3 of 40, or 13 board feet. The part lost amounts to 2/3 of the affected portion, or 2/3 of 13 = 8 board feet, which, when rounded off to the nearest 10 board feet, gives a deduction of 1. The net scale of the log is: 8 - 1 = 7, or 70 board feet. While this method sounds complicated on paper, an experienced scaler carries on all these calculations in his head while looking at the log and has no difficulty at all in making the deduction rapidly.

CROTCH.—Deduction for crotch in scaling logs is illustrated in view L, figure 6-23. Note that the piece lost due to the crotch is indicated in the illustration. It is taken out as a rectangle by the standard rule. At times the diameter of the log inside bark is measured below the swelling caused by the crotch. Frequently, however, the diameter below the swelling is not actually measured but is computed by subtracting a taper allowance from the diameter inside bark at the large end of the log.

Assume that the log shown in view L has a diameter inside bark below the swelling of 12 inches and a length of 16 feet, with a gross scale of 8, or 80 board feet. Assume, too, that the thickness lost inside the right cylinder and slab, a, is 5 inches; that the average width of the board lost inside the right cylinder and slab, b, is 11 inches; and that the length of the crotch is 3 feet, which will be called 4 feet if off-length boards are not merchantable. By the standard rule the deduction is—

$$\frac{5 \times 11 \times 4}{15} = 15 \text{ board feet,}$$

or rounded off to the nearest ten, 1. The net scale is 8 - 1 = 7, or 70 board feet.

Deductions for Defect Board Feet, Using the International 1/4-Inch Rule

In scaling logs by the international 1/4-inch log rule (table 6-3) the procedure is like that for the Scribner decimal C rule, with only such modifications as required by the differences in construction of the two rules. Since there is a deduction of 1/16 inch for shrinkage, in addition to the 1/4-inch saw kerf deduction, the standard rule for defect deductions becomes

$$\frac{a \times b \times L}{16},$$

in which a is the thickness or depth of the defect, in inches, b is the width of the defect, in inches, and L is the length of the defect, in feet. This rule is amply generous in its allowance for defect, and it is not desirable to add 1 inch to these dimensions for sawing around the defect. This applies especially to a circular defect for which the standard rule becomes—

$$\frac{D^2 \times L}{16},$$

in which D is the average diameter of the defect in inches, and L is the length of the defect in feet. Since the international 1/4-inch rule allows for a taper of 1/2 inch per 4 feet of length, the diameters of any defect appearing at both ends of the log should be averaged in obtaining D, regardless of the length of the log.

Unlike the Scribner decimal C rule, the international 1/4-inch rule does not set up a right cylinder outside of which no deductions should be made. Instead, it sets up a cone

117.227

Table 6-3.—Board Feet Content By the International 1/4-inch Log Rule.

Diameter (inches)	Length (feet)												
	8	9	10	11	12	13	14	15	16	17	18	19	20
	Contents (bd ft) in tens												
6.	10	10	10	10	15	15	15	20	20	20	25	25	25
7.	10	15	15	15	20	20	25	25	30	30	35	35	40
8.	15	20	20	25	25	30	35	35	40	40	45	50	50
9.	20	25	30	30	35	40	45	45	50	55	60	65	70
10.	30	35	35	40	45	50	55	60	65	70	75	80	85
11.	35	40	45	50	55	65	70	75	80	85	95	100	105
12.	45	50	55	65	70	75	85	90	95	105	110	120	125
13.	55	60	70	75	85	90	100	105	115	125	135	140	150
14.	65	70	80	90	100	105	115	125	135	145	155	165	175
15.	75	85	95	105	115	125	135	145	160	170	180	190	205
16.	85	95	110	120	130	145	155	170	180	195	205	220	235
17.	95	110	125	135	150	165	180	190	205	220	235	250	265
18.	110	125	140	155	170	185	200	215	230	250	265	280	300
19.	125	140	155	175	190	205	225	245	260	280	300	315	335
20.	135	155	175	195	210	230	250	270	290	310	330	350	370
21.	155	175	195	215	235	255	280	300	320	345	365	390	410
22.	170	190	215	235	260	285	305	330	355	380	405	430	455
23.	185	210	235	260	285	310	335	360	390	415	445	470	495
24.	205	230	255	285	310	340	370	395	425	455	485	515	545
25.	220	250	280	310	340	370	400	430	460	495	525	560	590
26.	240	275	305	335	370	400	435	470	500	535	570	605	640
27.	260	295	330	365	400	435	470	505	540	580	615	655	690
28.	280	320	365	395	430	470	505	545	585	625	665	705	745
29.	305	345	385	425	465	505	545	590	630	670	715	755	800
30.	325	370	410	455	495	540	585	630	675	720	765	810	555
31.	350	395	440	485	530	580	625	675	720	770	820	870	915
32.	375	420	470	520	570	620	670	720	770	820	875	925	980
33.	400	450	500	555	605	660	715	765	820	875	930	985	1,045
34.	425	480	535	590	645	700	760	815	870	930	990	1,050	1,110
35.	450	510	565	625	685	745	805	865	925	990	1,050	1,115	1,175
36.	475	540	600	665	725	790	855	920	980	1,045	1,115	1,180	1,245
37.	505	570	635	700	770	835	905	970	1,040	1,110	1,175	1,245	1,315
38.	535	605	670	740	810	885	955	1,025	1,095	1,170	1,245	1,315	1,390
39.	565	635	710	785	855	930	1,005	1,080	1,155	1,235	1,310	1,390	1,465
40.	595	670	750	825	900	980	1,060	1,140	1,220	1,300	1,380	1,460	1,540

frustum (a cone with its top cut off by a plane parallel to the base). The top diameter of the frustum is the top diameter inside bark of the log, and the frustum has a uniform taper of 1/2 inch for every 4 feet of log length. A collar of 1 inch in radial thickness is allowed for slabs within this frustum. Any defect or part of a defect falling outside the cone frustum or its slab collar is disregarded in scaling by the international 1/4-inch log rule. In conformity

with the method of constructing the rule, all deductions for defect are rounded off to the nearest 5 board feet.

HANDLING AND TRANSPORTING LOGS

The first step in getting the forest products to the mill usually involves dragging the tree trunks, or parts of them, to the landing, yard, loading ramp, or mill. This first step is called SKIDDING. A number of methods for doing this job have been developed through the years, ranging from crude hand methods to complicated engine and cable systems used in some of the larger operations. The method that is selected depends on the size and weight of the timber products to be handled, the type of ground to be crossed, the cut per acre, and the total amount to be hauled.

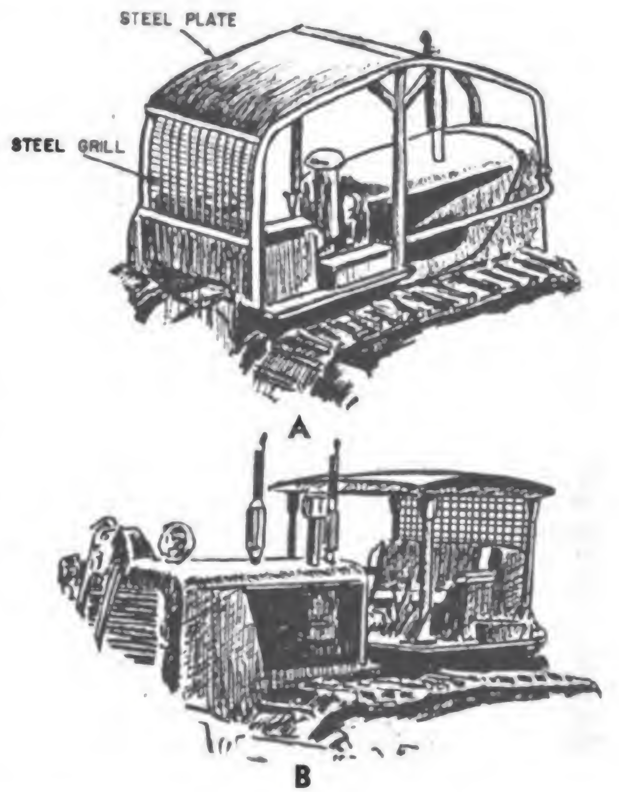
USE OF TRACTOR AND ACCESSORIES

The crawler tractor used for logging is equipped with a front-mounted power control unit and a rear-mounted winch. The rear winch is reversible and may be used to skid the logs from the stump to the skid road. The tractor is large enough, 17,100- to 24,000-pounds drawbar pull, to handle any skidding job encountered.

The tractor must be equipped with a steel guard for the underside of the crankcase, a heavy-duty radiator guard, and guards for the lower tracks and wheel bearings. If the tractor is operated without the angledozer blade, a heavy front bumper should be attached. It is usually advisable to remove the blade if extremely steep slopes are to be negotiated. The blade will dig in, hang, and gouge the roadbed.

Protection from falling tree limbs and from breaking cables is needed for the operator. Two guards that give this protection from overhead and from the rear are shown in figure 6-24. A guard of this general type is a safety requirement that should not be disregarded. The steel roof plates should be at least 1/4 inch thick. The grill behind the operator should be a 1- to 2-inch mesh of 1/4-inch rods.

For most purposes, a heat-treated one-piece shoe as wide as can safely be carried on the sprockets is desirable for the skid tractor. For winter use, a skeleton track with a hole about 4 to 6 inches in the center of each track plate helps keep the snow from packing on the tracks.



A. Overhead guard B. Rear guard

117.212

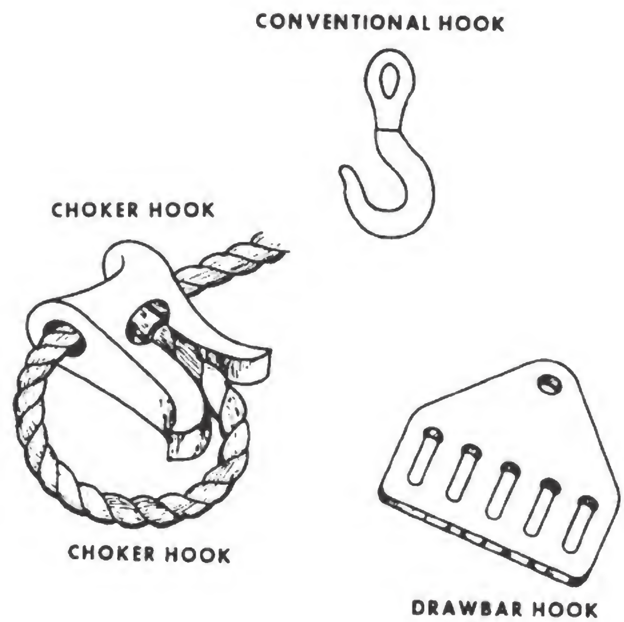
Figure 6-24.—Guards to protect the tractor operator.

In addition to the single-drum, reversible winch normally supplied with the crawler tractor, there is available a tractor-mounted, three-drum, two-speed winch designed specifically for the logging operation. This winch is called a tractor donkey and consists of the following:

- Main drum with a 1-inch cable capacity of 960 feet.
- Haulback drum capable of holding 2,360 feet of 7/16-inch cable.
- Strawdrum capable of holding 2,940 feet of 5/16-inch cable.

CHOKERS AND CHOKER HOOKS

A choker is a short length of flexible wire rope used for skidding logs (see fig. 6-25). One end is fastened to the log by means of a sliding loop attached to a swivel; the other end



117.213
Figure 6-25.—Choker and choker hooks.

is fastened to the tractor. The swivel should be used since choker cables, without swivels, used for towing logs tend to deteriorate rapidly due to the rolling and turning action of the towed log.

A CONVENTIONAL HOOK (see fig. 6-25) on the end of the choker makes the choker easier to attach to a log. If the hook is constructed properly, it causes less wear on the cable than a spliced eye does. However, a hook becomes disengaged rather easily, often resulting in loss of all or part of the load.

The CHOKER HOOK, illustrated in figure 6-25, is the best device for securing logs. Its construction allows the cable to run freely through the sleeve when the log is secured.

The DRAWBAR HOOK, also shown in figure 6-25, can be attached directly to the tractor drawbar or secured on the end of the logging winch wire rope. The chokers are attached to the hook.

By means of clevises, one or more of the choker hooks can be attached to an eye loop making possible the use of chokers with ferrules at both ends (see views A and B, figure 6-26). These have the advantage of being reversible, and they wear longer and more evenly. Three or four short lengths of chain can be used to multiply the number of chokers that can be attached (see view C, fig. 6-26).

GROUND SKIDDING

Tractors can be used for skidding logs on the ground; however, ground skidding should be avoided whenever other methods are available. A number of methods are used in securing logs for ground skidding. They include slip chains, skidding tongs, crotch grabs, and grabs, as illustrated in figure 6-27, views B, C, D, and E.

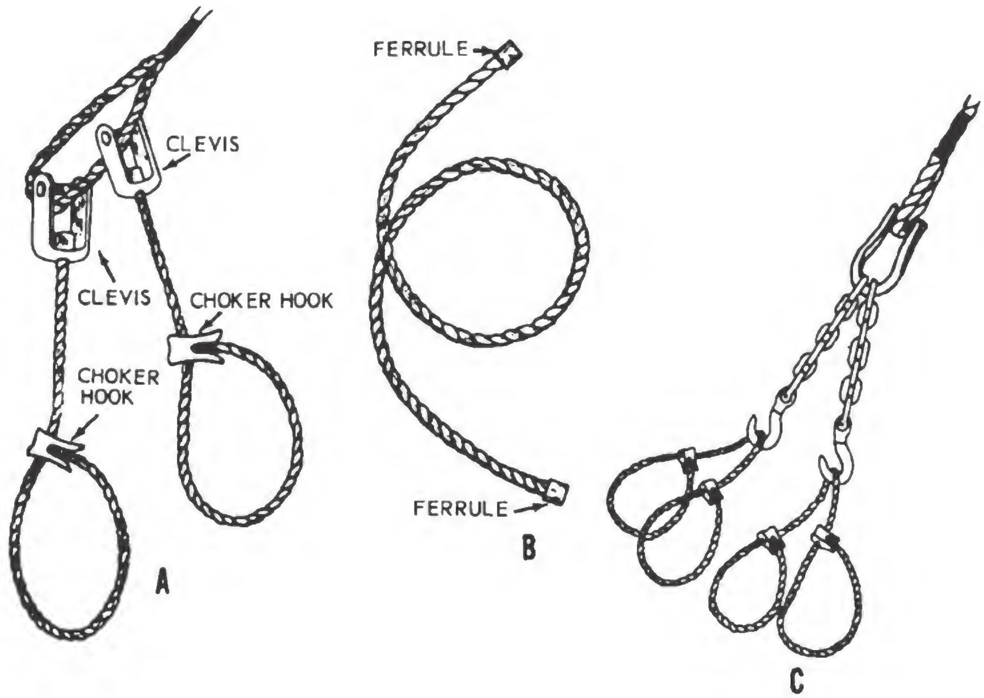
In skidding LIGHT LOGS and POLES, a 10- to 12-foot chain is used with a slip hook on one end and a clevis on the other. The logs are secured with the slip hook and chain as shown in view A, figure 6-28. The chain must be far enough down the log so that it does not slip off when it is pulled tight, as illustrated in view B, figure 6-28. The towing chain is kept as short as possible in order that the pulling action of the tractor will raise the ends of the logs slightly to prevent their digging in as they are skidded.

For ground-skidding HEAVY LOGS, the slip-chain hitch can be used. However, the increased friction of a heavy chain across the underside of the log makes it harder to move. The crotch grab (D, fig. 6-27) and skidding tongs (C, fig. 6-27) are usually more adaptable to heavy work.

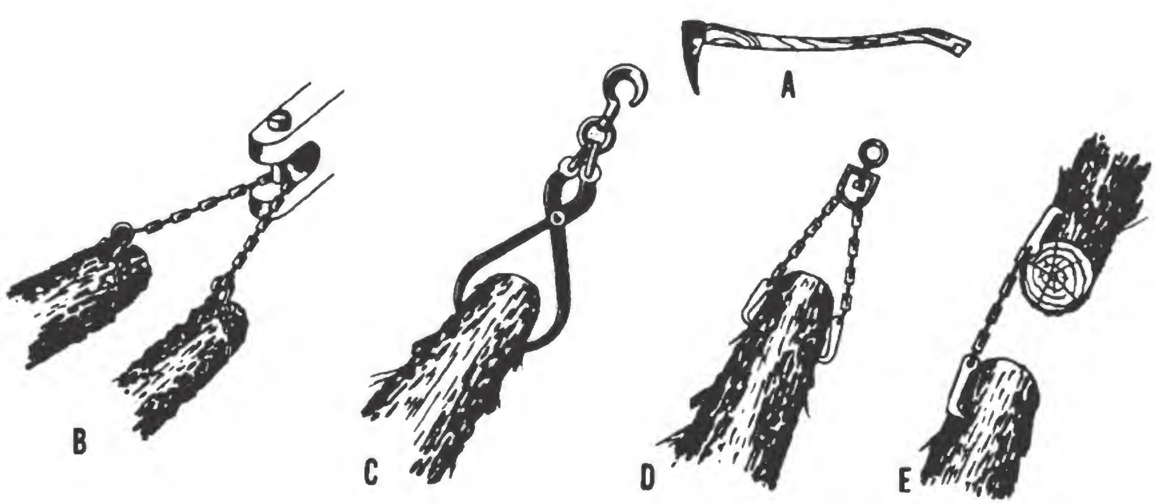
When the crotch grabs are used, the grabs are placed in position on the side of the log and a hookaroon or grab skipper (A, fig. 6-27) is used to drive them into the log. The grabs must be located down the log far enough so that they will not split out when the skidding begins. To remove the grabs, the sharp end of the hookaroon is used to pry them free of the log.

When the skidding tongs are used, the tongs are set in position on the log with sufficient "bite" to take hold when the skidding begins. Sometimes it may be advisable to set the tongs with a maul. To remove the tongs, the strain on the towing chain is slackened and the tongs will fall free with a small amount of prying.

The grabs may be used to form a train of logs, as indicated in E, figure 6-27. The grabs are set in position in the same way the crotch grabs are set. Care must be exercised in locating the grabs so that when skidding starts the logs do not roll over and thereby become fouled

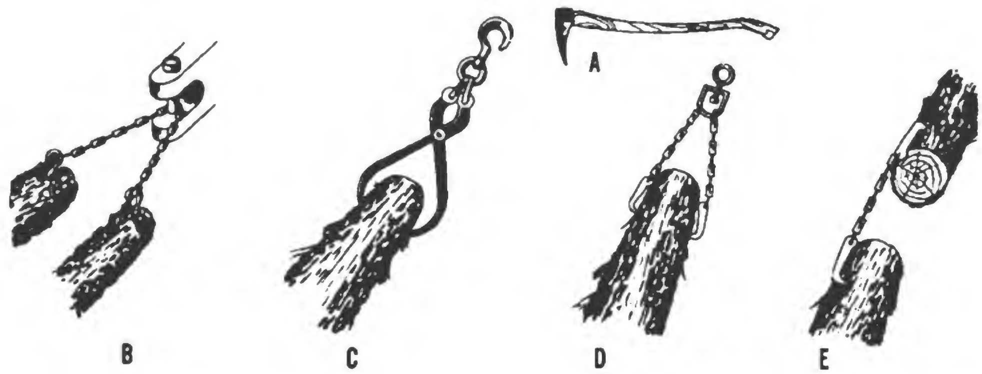


117.214
Figure 6-26.—Choker hook rigging.



A. Hookaroon
B. Slip chains
C. Skidding tongs
D. Crotch grabs
E. Grabs

117.215
Figure 6-27.—Securing logs for ground skidding.



A. Hitch for several small logs. B. Hitch pulled tight.

117.216
Figure 6-28. — Hitch for light logs and poles.

in the ground. The grabs are removed with a hookaroon.

Logs of small size are sometimes seriously damaged when tongs or grabs are used. If it is necessary to use tongs or grabs on small logs, sufficient allowance must be made for this damage when the logs are bucked.

Do not skid logs on the ground behind a tractor for distances over 500 feet because of the friction and time involved. For longer skids an improvised anti-friction device or logging arch will increase the load capacity and greatly speed up the operation. For short skids, and where numerous turnarounds are necessary, the tractor has greater maneuverability without a trailing device.

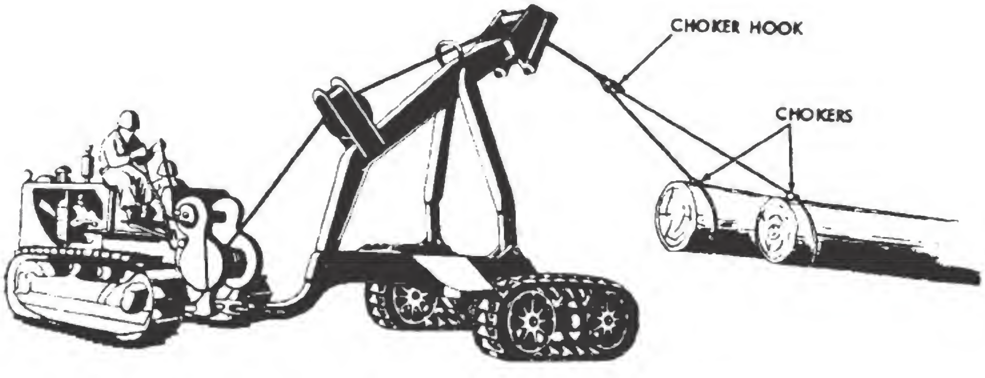
Logs skidded on the ground will hand on obstructions more than a few inches above ground level. Make sure that these obstructions are avoided or, if encountered repeatedly, removed.

For winching the log from the stump to the skid road, hitches with chokers, chains, tongs, or grabs may be used. The logs may be winched individually or in a bunch. The operator of the winch will need an assistant to secure the log at the stump and to walk with the log as it is drawn towards the tractor. The assistant should aid in getting the log around obstructions and at the same time give instructions to the winch operator. Logs are seldom winched over 200 feet because of the many difficulties encountered in skidding the logs through heavy underbrush and around trees and stumps.

SKIDDING WITH TRACTOR ARCHES

The best rig for skidding logs is the tractor equipped with a winch and logging arch (see fig. 6-29). The cable from the tractor winch, called the dragline, runs up the top of the reach and through the fairlead. The fairlead allows logs or poles to be pulled in from the sides for bunching, and then to be pulled up into the arch for skidding to the truck or yard.

The most important factor in efficient use of an arch in the woods is to make sure that the trees are felled in the right direction. This usually means dropping them at an angle of up to 45° to the road, away from the direction in which they are to be hauled out. If they are dropped in this manner, the choker setter (member of the logging crew who places the chokers on the logs) can roll them from behind stumps or other obstructions and attach the chokers; then the tractor winch can quickly and easily pull the logs to the road. In bunching this way, logs pulled uphill are under better control and do less damage to the timber left standing. On some operations it is more efficient to have another tractor bunch the logs at the side of, or, in the skid road. This is done in unusually rugged, rocky country where tractor skid roads are difficult or expensive to make, or where extra heavy tractors are being used on long hauls. Usually it is more economical to place the tractor skid roads close enough together so that the tractors can do their own bunching, and fell trees so that they can be dragged out most easily.



117.217
Figure 6-29. — Tractor and arch skidding.

LOADING

Loading forest products for the haul to the mill presents many problems in the design of the loading facilities for each location and each type of log handled. The variety of conditions under which loading has to be done adds to the number of systems and devices developed to help do the job. Loading can be either "hot," with the wood going onto trucks or sleds just about as fast as it is skidded from the woods; or "cold," with the wood accumulating at a yard or landing in quantity before it is to be loaded. Loading can be done on a level spot, or on a hillside from above or below the road. The material to be loaded may be short bolts, logs of various lengths, or entire tree lengths.

Loading Short Bolts

For handling limited amounts of short bolts, hand loading will generally suffice. However, if large amounts are to be handled, a system of mechanical or semi-mechanical loading should be devised.

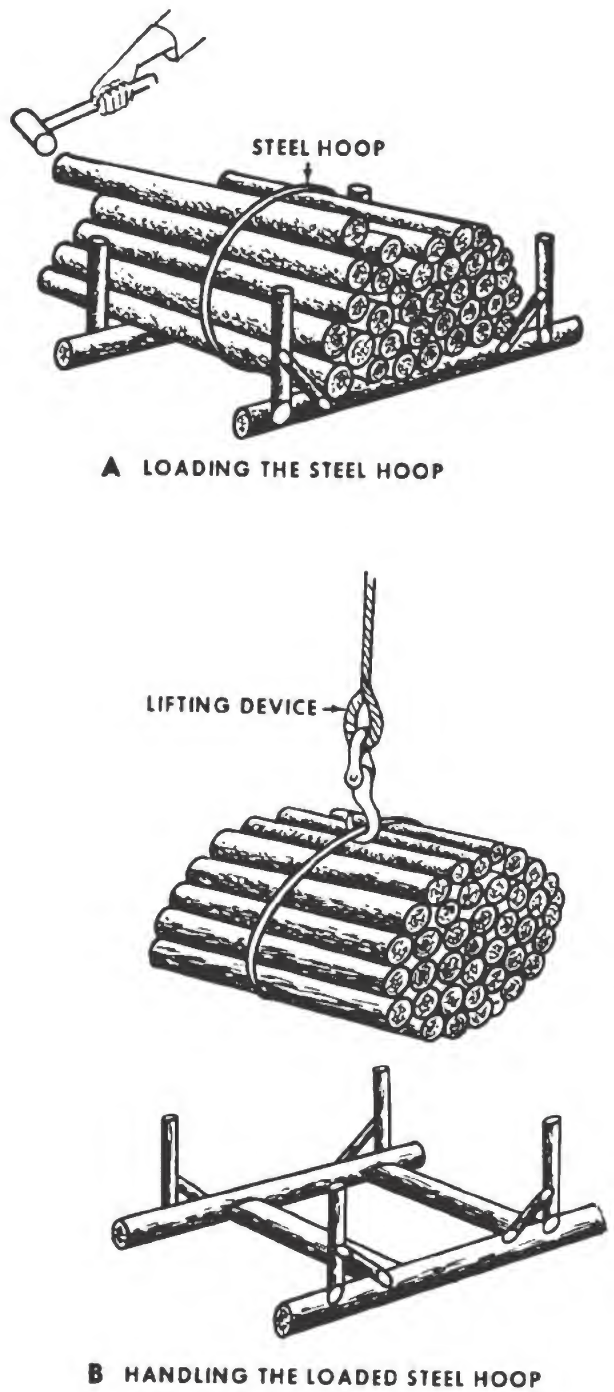
One method (A, fig. 6-30) that reduces handling of bolts to a minimum is the steel hoop and cradle. Here the wood is piled by hand in cradles in the middle of which welded hoops of steel reinforcing rods have been set. The last few bolts are pounded in with a mallet. The wood is then handled (B, fig. 6-30) in these bundles in its transhipments. The hoops can be used again and again. These cradles are loaded at the point the bolts are cut and then skidded to the loading area.

The above method of handling bolts is just one of the many ways of doing the job. You, as logging supervisor, can improvise as necessary to get the job done. If equipment is available, the use of forklifts, small crawler tractor-mounted cranes, improvised conveyor systems, and improvised trucks and trailers will save manpower and greatly increase the speed of the operation.

Loading Sawlogs

Logs and poles generally are too heavy to be lifted by hand for loading, although some small logs are loaded in this way. Usually, they have to be rolled or hoisted onto the bed of the truck or trailer. Logs can be rolled up inclined skids to the truck bed with the aid of a cant hook or peavy. Two men, one to hold the log while the other is getting a fresh grip, can do this with considerably more ease and safety than one man working alone. Spikes or notches in the skids help hold the logs from slipping and rolling back.

In hilly country a loading point can usually be found where skids can be placed level between the slope and the bunks (crossbeams upon which the logs rest) of the trunk. This may require long skids, which are apt to break. The best method of loading from the side of the hill is to construct a skidway out of cull logs. Such a skidway may be either single- or double-decked. As shown in figure 6-31, the double-deck skidway can best be utilized because it allows the logs to be loaded at different heights. When the truck arrives, the logs from the first deck are loaded in the first tier or two on its bunks. Then the skids are moved up between the next deck of the skidway and the top of the logs already loaded, and a third and



117.218
Figure 6-30.—A method of handling short bolts.

possibly a fourth tier of logs can be loaded. Over long spans, a catwalk or plank from the skidway to the truck is sometimes provided for the log rollers to work on.

On level ground, the cross-haul method can be used. Figure 6-32 illustrates the use of a small crawler tractor to pull the logs up the skid onto the bed of the truck. If there are a great many logs to be loaded at the same location, a small skid-mounted winch should be substituted for the tractor.

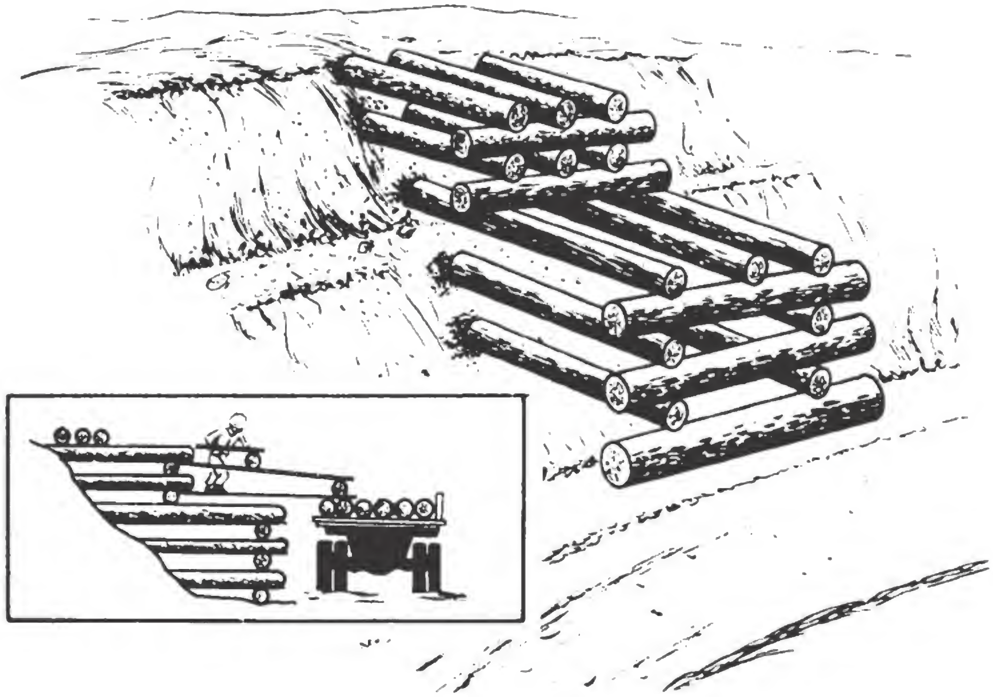
If a great deal of loading is to be done at one place and the logs are of medium to large size, a more permanent type of loading device should be considered. The double-tong device is the safest and fastest for the permanent type loading rig. Two such devices are the McLean boom and the crotch-line loader.

The McLean boom is illustrated in view A, figure 6-33. When this device is to be used, a spar must be erected, or a spar tree must be topped and guyed. The boom consists of two sturdy poles, braced and secured as shown. If a counterweight swing is used, as illustrated, only one swing line is needed to carry the boom and its load to its position over the truck to be loaded. The counterweight swings it back when the single swing line is reeled out. The line to the lifting tongs is arranged on the hook of the boom loading block with one turn (to prevent slippage), so located that one portion of the line is sufficiently longer than the other to provide lifting of the two tongs simultaneously. Power for this device can be provided by a double-drum winch on the back of a crawler tractor, or by a similar skid-mounted winch.

The crotch-line loading system requires two spars, both provided for picking up or dropping the logs at any point between them (see B, fig. 6-33). The usual system is to have the log supply at one side of this space and truck road at the other. The spreader for the tong lines is usually a length of old rail, with holes bored at either end for the necessary clevises. The power for this device can also be supplied by a double-drum winch either tractor- or skid-mounted.

Loading Tree-Length Logs

Various devices described can be used to handle tree-length logs. In addition, crawler-mounted cranes and stationary gin poles can also be used. The stationary McLean boom and the crotch-line loader are especially well adapted for loading tree-length material.



117.219
Figure 6-31.—Double-deck skidway.

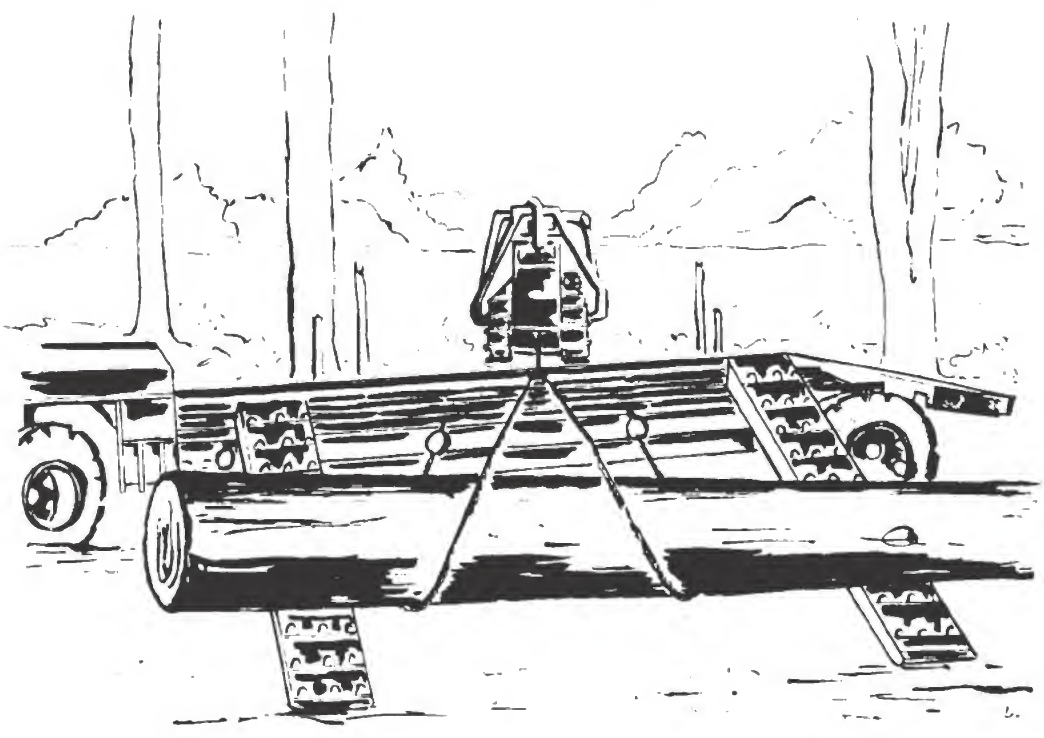


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Figure 6-32.—Cross-haul method of loading sawlogs.

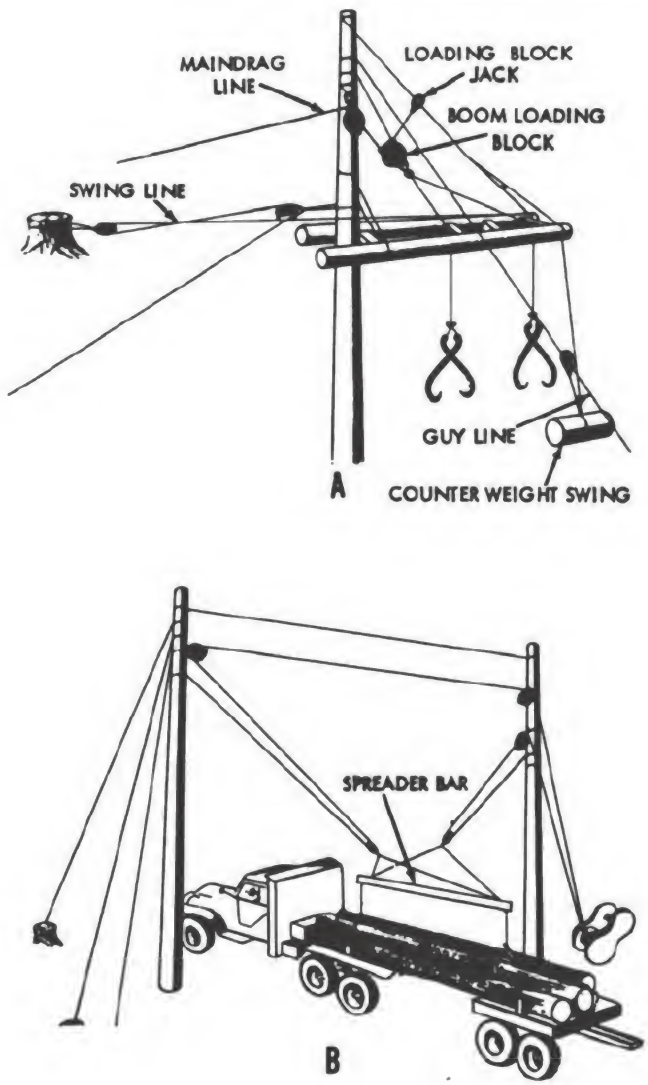

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Figure 6-33. — Permanent type loading devices.

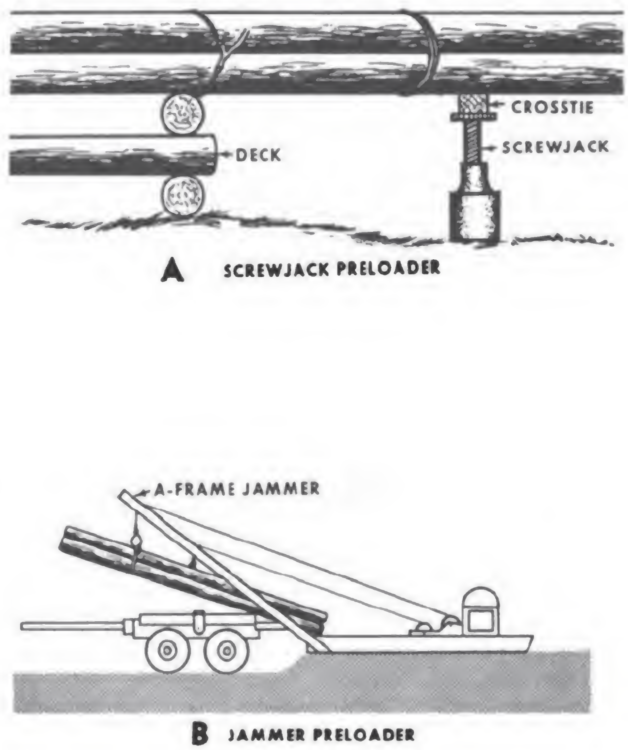

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Figure 6-34. — Two types of log preloaders.

Preloaders

The screwjack type of log preloader, shown in view A, figure 6-34, is peculiarly adapted for use with tree lengths. The screwjack raises the tree-length logs slightly above the level of the truck body. The truck is then backed under the ends of the logs extending beyond the screwjack and the screwjack is removed. The truck is then backed again until the logs are properly loaded on the bunks. Most of the devices suspend the load in such a position that the truck can be backed under it and the load dropped on the bunks, chained down, and hauled away. The advantage is that the truck does not have to wait while its load is being assembled. Also, the loading crews can work at a steadier, safer pace, instead of waiting for a truck to be loaded and get on its way.

Logs can be assembled on a preloader by rolling by hand, by a jammer, or by a crane. A special jammer built for assembling loads and then lifting the front end of the load while the truck backs under is shown in view B, figure 6-34. This machine assembles the load from the log yard. It uses two tong lines, each attached to a separate winch. It is possible to move the tree lengths around from almost any position and place them in front of the preloader with one end resting on the crosspiece between the boom legs and the other on the ground. When a load has been assembled and a truck arrives, a wire rope sling with spliced eyes in either end is passed under the front end of the load and hooked onto the two prongs of the front tong. Then the line going to this tong is tightened, raising the front end of the load so that the

truck can back under it. The load is eased down onto the front bunk. The cable can then be removed and the load secured to the truck.

Wire Rope Used For Loaders

In all loaders that pick up the log and swing it through the air, special attention should be given to the wire rope and the sheaves and fittings used with it. For economy, speed, and safety, wire rope of adequate strength should be used, together with the proper fittings. Clips to fasten wire rope should not be used on loaders, particularly on live lines, because they cannot be expected to feed through sheaves properly, or to develop sufficient strength for lead and swing lines. Blocks of the right design and of sufficient diameter should be used.

Wire rope on loaders is often subject to many jerks. Consequently, it is best to use 6 by 10 preformed plow-steel rope of a diameter that will carry the intended loads with an ample safety factor. It should be lubricated frequently and thoroughly. Special care should be given to spooling it evenly on the drums, making sure that it is not subject to unnecessary abrasion in blocks and sheaves. Periodic and careful inspections should be made of all rope in use. Kinked, badly abraded, crushed, or nicked rope should be cut out and discarded, or put to some less important and less dangerous use.

UNLOADING LOGS

Long logs usually are unloaded by driving the load up alongside the landing place or pond on a tilt, releasing the stakes or bindings, and letting the logs roll sideways off the bunks. As a rule, some of the logs must be rolled off with a cant hook. With long logs, a level landing bed is advisable to prevent breakage. Level dirt provides a springy landing, if it does not contain rocks. Where there is a steep slope down to a log pond, a permanent rollway of round or square timbers at a decided angle is more satisfactory, since it keeps the rolling logs from undermining the rollway and carrying dirt into the pond.

Where space is limited, and there is no pond, logs are frequently decked in the yard by a crane, crotch line, or A-frame high-lead. Usually, they are dumped off the trucks and picked up by the device being used, but in some cases they are picked off the truck bunks either individually or in bundles.

Another system of unloading is to use a crawler tractor with an improvised pushing device mounted on the front end. This device is mounted similar to a bulldozer blade and consists of three or four steel rails welded vertically to the horizontal blade support.

MOVEMENT OF LOGS BY WATER

The use of waterways provides the least expensive way of moving logs from the forest. Wherever possible, this method of moving logs should be considered, especially if the timber stand is located in an isolated place. Appropriate precautions should be taken when working in or over water.

In general, softwood species float and hardwood species tend to sink. This is not always the case, so it should be determined whether each species to be cut is floatable. A good method is to cut one of the trees and see if it will float. In many instances it is possible to float nonfloatable logs by mixing them in rafts with floatable species.

In mountainous areas, swift-running streams, fed by melting snow and seasonal rains, can be used if there are not too many rapids and short turns. If the water level in a stream changes rapidly, the depth and width of the stream will be affected and many logs will be stranded and lost. The chief advantage of moving logs along streams is that it alleviates the need for building skid roads and, in most instances, lessens the time required for moving the logs from the forest to the mill. Disadvantages are the losses due to sinking, stranding along the banks and in marshy areas, and breaking in jams and on obstructions encountered in the streambeds. The best criterion for the use of swift-running streams is to investigate whether or not the streams have been used in the past for driving logs. Since stream driving is the cheapest method of moving logs it would have been used if at all feasible. In the absence of local information, the decision on the use of a stream will be the responsibility of the person in charge of the logging operation.

In the delta areas of nearly every continent, particularly in the tropical and semitropical countries, the forests are transversed by wide, slow-moving rivers. The typical land areas are low, densely vegetated swamps or marshlands. Roadbuilding through these areas is a slow and costly process because of the insecure ground and dense vegetation. Log rafts can be

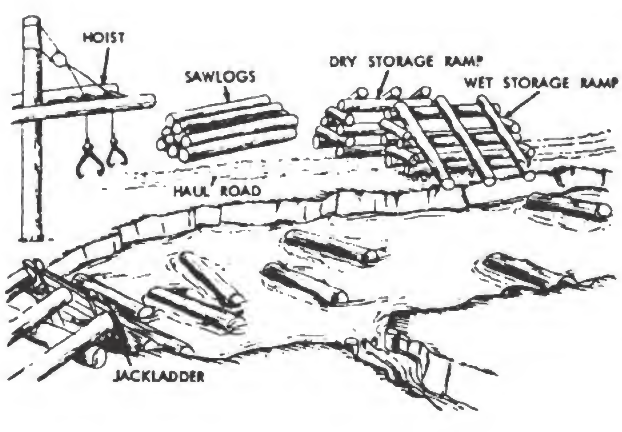
made up at convenient points along the river and towed to the mill site or loading dock. The rafts should be bound together with wire rope or chains. The towing line between the raft and the towing vessel (usually a light bridge-erection boat) should be long enough to allow for full maneuverability of the boat. Also, the towing line should be attached to the boat in such a manner as to allow for quick detachment in case an emergency should arise warranting release of the load.

WET STORAGE

Streams, lakes, ponds, or log troughs can be used as wet storage areas for logs. Usually, it is best to use an existing facility since the construction of a dam for a pond or an excavation for a log trough can develop into an expensive and lengthy operation. In areas of extreme cold, wet storage can become a serious problem when ice forms over the storage area. Facilities for artificial warming or mechanical icebreaking must be considered during the planning for the sawmill site.

As for the size of the wet-storage area, note that about 150,000 board feet can be floated per acre of pond. Nonfloating logs should not be stored in large wet-storage ponds as recovery of sunken logs is a difficult and time-consuming job.

The wet-storage area must be situated so that the log-hauling trucks can approach and leave the unloading ramp without difficulty. (See fig. 6-35.) If possible, the unloading ramp should



117.223
Figure 6-35. — Layout of a wet-storage facility.

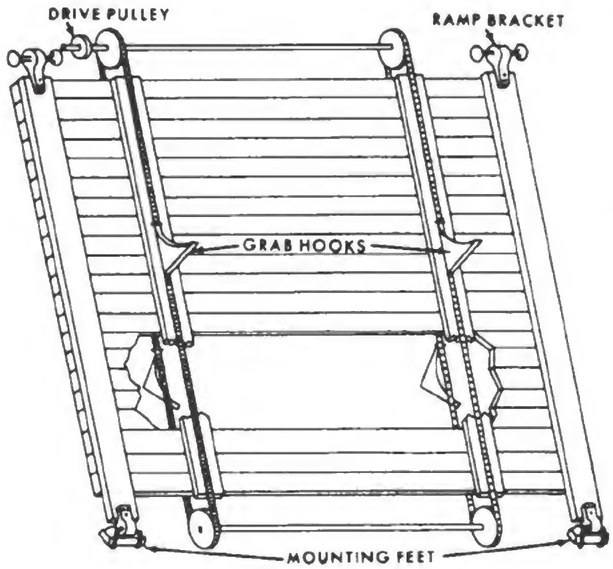
be planned to extend along one side of the pond so that a dry-storage ramp can be built along the opposite side, parallel to the wet storage ramp. Planning the log storage yard in this way will facilitate the handling of logs intended for either dry or wet storage.

Relatively small ponds holding only a few hours supply of logs for the sawmill are used for species that sink as well as floaters. The purposes of this ponding are to wash grit and abrasives from the logs, thaw frozen logs, and provide a practical means of separating and feeding logs to the mill. Such ponds are either blocked off from larger water bodies or are constructed at the millsite. The conditions sought, in addition to stable water levels, are a pond permitting all logs to be reached from the margin with long pike poles, a depth limited to adequate log floatage, and a length to contain the required log volume. For logs not more than 16 feet in length, a 20 foot width, a 5 foot depth, and a length of between 50 and 150 feet will usually suffice for a small sawmill operation. The sides of the pond should be vertical and stabilized by cribbing, planking, or concrete construction. A spillway should be planned that safely carries off excess water. Also necessary are gates or outlet pipes for draining when cleaning is required.

Logs can be conveyed from the pond to the log deck (platform by sawmill upon which logs are collected and stored previous to placing them on the sawmill carriage for sawing) by means of trams, conveyor chains, boom hoists, or sling chains. A simple device suited to small-mill production is a jackladder, as illustrated in figure 6-36. The jackladder must be firmly anchored at the base by piling or a concrete slab and secured at the top of the log ramp.

LOGGING UNDER UNUSUAL CONDITIONS

The mechanized equipment that you will use in logging operations is generally adaptable to almost every climatic condition. Under certain extremes of climate, modifications of the equipment may be necessary, such as the installation of snow plows on wheeled and tracked vehicles. For the most part, it will be necessary to obtain additional equipment in order to cope with particular situations. An example of this is the use of a bridge-erection craft as the motive power for a log raft.



117.224
Figure 6-36.—Jackladder for hoisting logs sidewise from pond to deck.

SAFETY

Some of the precautions that should be observed by personnel engaged in handling and transporting logs are listed below. As a logging foreman, bear in mind the dangers involved, and ensure that all men under your supervision KNOW and FOLLOW the safety precautions applicable to their job.

Skidding Crew

The tractor operator should be responsible for the condition of the rigging, and see that chokers or winch lines with broken strands are not used.

It should always be made certain that all workers are in the clear before moving the tractor or winch.

Lines on cable systems should NOT be guided with the hands while the line is being wound on the winch drum.

The skidding-tractor operator should check the overhead guard (A, fig. 6-24) daily to make certain that it has not been broken through vibration or use.

The skidding-tractor operator should at all times be alert to catch signals from the rigging slinger and to be positive that these signals are understood. Hand signals should be clear so that there is no chance for a mistaken meaning.

When skidding off a steep slope, the rigging slinger must be in the clear, especially when pulling at an angle, since such a pull has a tendency to roll the logs.

If, in the judgment of the tractor operator, the situation is not safe even though he has the signal from the rigging slinger, he should not pull.

Any logs which stick out into the skid road so that they interfere with the skidding should be taken out in the first drag (collection of logs, chokered, and attached to a towing vehicle), if possible, to give a clear and safe skidding road.

When working in deep snow, it is hard to move fast in the brush, and the rigging slinger should set the hook in the choker and come back to the skid road before yarding the log.

Under no circumstance should either the choker setter or the rigging slinger ride the drag.

Choker setters and rigging slingers should not remain on or near the rear of the tractor and the drag while the winch is in use.

It is extremely dangerous to stand near the skid road while the tractor pan or tractor and drag pass. Unexpected action of the pan can only be avoided by standing completely clear of the skid road.

If a crawler tractor must be left unattended on a slope, it should be turned so it will not be able to roll down the hill uncontrolled. Even though brakes are set, vibrations may loosen the ratchet.

All mechanical failures should be repaired immediately. This includes breakage, poor performance, loose controls, or the presence of anything which may be a hazard to the skidding crew.

If it is absolutely necessary for rigging men to ride the tractor, they should be permitted to ride on seats only, and the operator should be responsible for their safe riding position. Rigging men should not get on or off the tractor while it is moving.

Loading Equipment Operator

Only an authorized and trained person should operate any loading equipment.

All cables should be inspected daily and all defects corrected.

At least three wraps of hoist line should be on the drum before any heavy pull is made.

The engine should be shut off during servicing or repair except for adjustment or diagnosing of trouble.

Equipment windows should be kept clean at all times.

Hookers or Tong Setters

The hooker nearest the loading equipment should give all signals to the operator while visible (except those the truckdriver must give to put the log in its proper notch). When the hooker is out of sight of the operator, he should transmit signals through the other hooker or truckdriver.

The hooker nearest the loading equipment hooks his end of the log last, and indicates to the operator when the log is to be hoisted.

Activity in regard to unhooking of chokers or hoisting of logs should be confined to one side of the load at a time.

No work should be permitted while a load of logs is leaving the landing.

No logs should be hoisted while the skidding tractor is pulling loose from the drag.

Hookers should concentrate on the log while it is being transferred from the drag to its notch on the load.

No logs should be hoisted while the knot bumper (limber) is limbing the logs on the drag.

It should be the responsibility of the landing crew to keep the landing clear of all chunks, logs, limbs, and debris.

Where running lines are used, they should be placed in such a position that men are not in the bight of the line.

If a log must be guided, a handline should be used and controlled from the ground to one side.

Personnel should not stand so that logs will be swung over their heads.

Personnel should stand in the clear when trucks are being spotted.

Truckdrivers

The truckdriver or top loader is responsible for the load. The loading equipment operator places the log where the truckdriver or top loader indicates.

Logging trucks and trailers should be equipped with stake bunks or bunks with chockblocks or both, with a height of at least 8 inches above the edge of bunk. Chains of sufficient strength to withstand the maximum imposed impact should be used. The gear should be so constructed that the chockblock can be released from the opposite end of the bunk.

Logging trucks should be loaded in pyramid form so that the center of the outside logs of each succeeding tier is inside the center of the outside log of the tier below. If stakes are used, the pyramid should start with the first tier above the top of the stakes. The load should be stable without binders and well balanced over the center of the bunks.

When trailers are loaded on trucks for the return trip to the woods, they should be securely fastened to the truckbed rather than being pulled behind the trucks. No truck with trailer loaded or a high load of logs should be backed without a signal from the head loader, or some member of the landing crew, since the trailer or load of logs will interfere with the driver's vision.

Logging trucks and trailers should be equipped with brakes that will safely stop and hold the maximum load on all steep grades.

Truck tires worn beyond a point of safety should not be used.

While loading, no person other than the top loader or truckdriver should be on the truck.

No loose tools or equipment should be carried inside the vehicle.

The horn should be sounded when the load is leaving the landing.

Drivers should not unhook or loosen wrappers before the unloading line is tight.

CHAPTER 7

SAWMILL OPERATIONS

As a Builder First Class or Chief Builder, you may be placed in charge of crews performing operations at the sawmill and lumberyard. This chapter contains information that will be useful to you as a guide in supervising these operations. We will cover major components of the sawmill. Primary duties and responsibilities of crews assigned to the sawmill also are pointed out. Instructions are given in sawing hardwood and softwood logs, edging, trimming, and so on. Information on the maintenance and upkeep of saws also is presented. You will be briefed on the layout of the lumberyard, as well as methods used in piling lumber. Among other things, this chapter contains safety precautions applicable to the sawmill and the lumberyard. Bear in mind that here we are especially interested in equipment, procedures, and related details which will help ensure that the various operations are carried out properly. Various factors covered in the chapter on foremanship (ch. 9 of this text) will also apply in supervising sawmill and lumberyard operations.

SAWMILL COMPONENTS

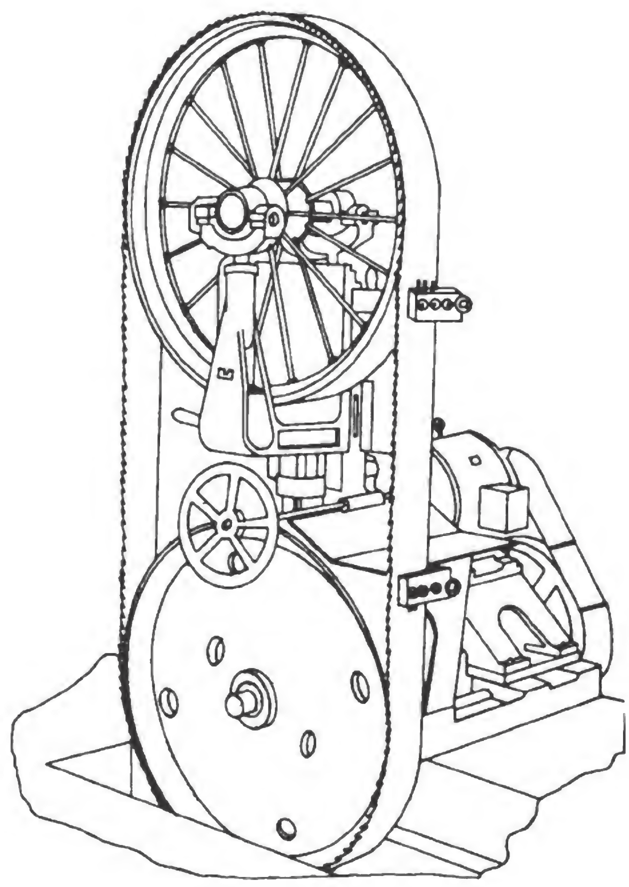
The sawmill consists of various components. Some of the major components and their function are described below.

HEADSAW

The headsaw is the saw which cuts the log into boards. Three types of headsaws in use are the circular, sash-gang, and band. Various arrangements of circular saws have been used including single-circular with or without a top saw, twin-circular, and gang-circular. The most common arrangement is the single-circular without a top saw.

The CIRCULAR HEADSAW is the most common type of headsaw in use. It consists of a flat steel disk with the saw teeth cut around the circumference. The saw is mounted on a shaft to which power is applied. The log is cut into boards by successive passes through the saw. The circular saw is highly flexible for cutting various thicknesses of the highest grade.

A SASH-GANG HEADSAW is a series of vertical reciprocating saw blades. As the log is fed through the saw it is cut entirely into



117.228
Figure 7-1.—Bandsaw.

boards on one pass. The sash-gang saw has a high cutting accuracy and recovers more lumber from each log than other headsaws. The primary disadvantage of the sash-gang saw is its inflexibility in cutting to various thicknesses.

A BANDSAW (fig. 7-1) consists of an endless belt or band of steel with saw teeth cut on one edge. The belt rotates over two vertically mounted pulleys, one of which provides the power for the saw. Band saws are normally fixed-type installations which produce an average of 3,000 to 4,000 board feet per hour.

HEADSAW GUIDES

Headsaw guides (fig. 7-2) are used on circular saws to steady the saw. The guide is mounted on the husk timber next to the track on the sawyer's side in either of two positions, depending on the size of saw used. It has two adjustable arms, each holding a wooden guide pin which contacts the saw when it is not properly adjusted, and a locking device to hold the adjustable guide arms in place once they are adjusted. The saw guide, when properly adjusted, clears the saw by approximately 1/32 inch on both sides of the rim of the saw.

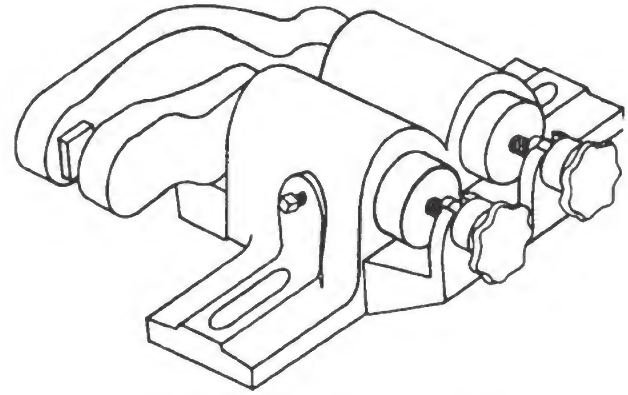
HUSK AND MANDREL

The HUSK is a box-like frame of wood or metal that supports working parts of a circular headsaw, including the mandrel and usually the feed-works mechanism. Two bearings are provided for mandrels up to 6 feet in length and additional ones are added for longer mandrels. Provision is usually made to fix the husk to supporting horizontal timbers, or sills, with bolted metal brackets. In some models, brackets are also used to hold the track and husk in a fixed relationship.

The MANDREL is a mechanical, hardened steel shaft carrying the saw, several pulleys, and possibly a flywheel. The mandrel is commonly belt-driven but direct drives are also used. Clutches may be placed in the mandrel so that the saw can be shut down independently of other machines. The saw is clamped between a fixed saw collar sealed to the end of the mandrel and a loose collar held by big pins and bolted on the mandrel.

CARRIAGES AND TRACKWAYS

The carriage is a movable truck on which the log travels to the saw. The carriage consists of two main parts, the carriage frame with wheels and axles, and the superstructure by means of which the lateral movement of the log toward the saw is controlled. This superstructure may be either the log-beam or the headblock type. The carriage framing is of heavy timbers or metal beams. This framework is mounted on four heavy trucks and truck axles which work in roller bearings mounted on the under side of the framework. One wheel is usually pressed on each axle. These wheels are either ground or flanged so that side play of the carriage is eliminated.



117.229
Figure 7-2.—Headsaw guide.

The LOG-BEAM mechanism (fig. 7-3) operates on several bases made of light metal or timber beams. These beams are mounted on top of the carriage framework. The log-beam mechanism consists of a beam which extends the length of the carriage, and on this are mounted several knees of varying types to which are attached different kinds of dogs for holding logs and cants. The log-beam mechanism moves at right angles to the length and travel direction of the carriage, thus pushing the log into the saw according to the thickness desired to be cut.

The HEADBLOCK type superstructure (fig. 7-4) for the carriage consists of two or more bases fastened to the frame. In each base slides a knee; each knee is connected to a mechanism for pushing the log into the saw. With this type only the knees move back and forth across the carriage.

FEED WORKS

Small-mill feed mechanisms, by which the sawyer controls the rate of log feed to the

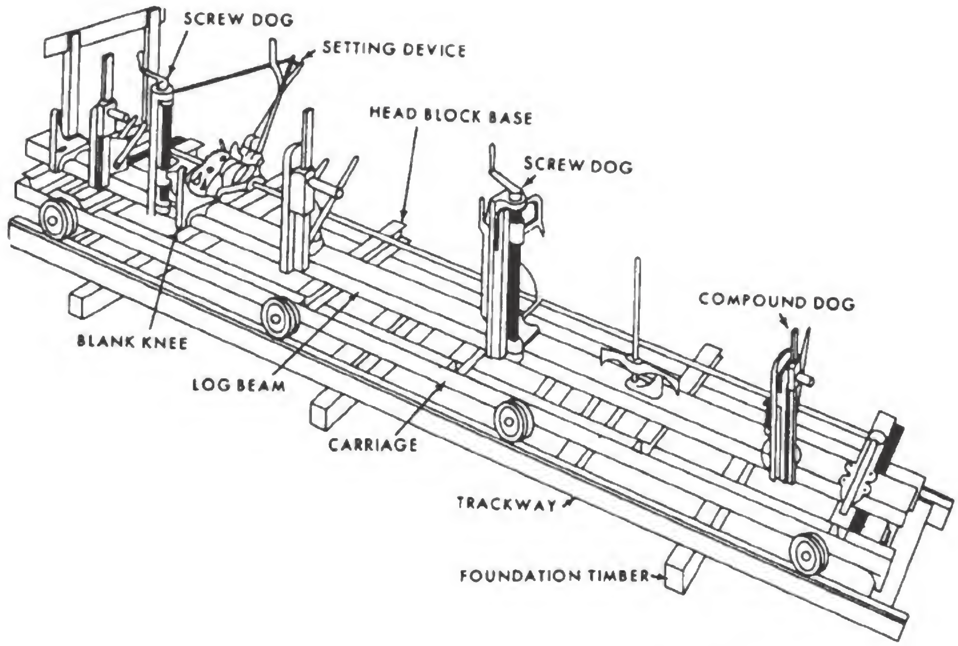


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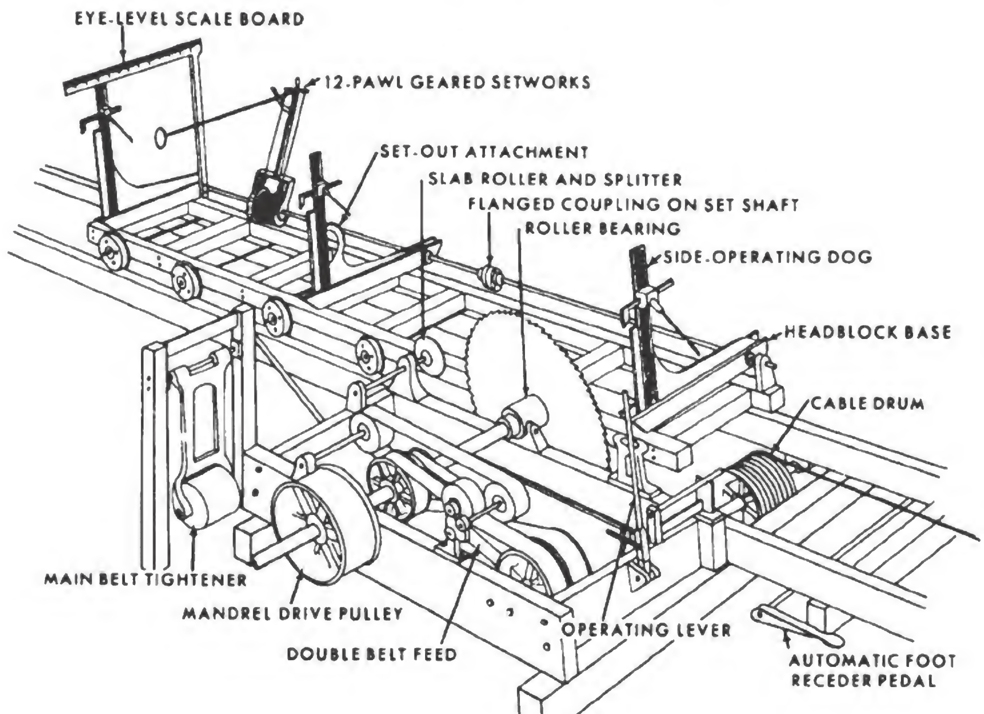
Figure 7-3.—Log-beam type carriage.



117.231
Figure 7-4.—Headblock type sawmill.

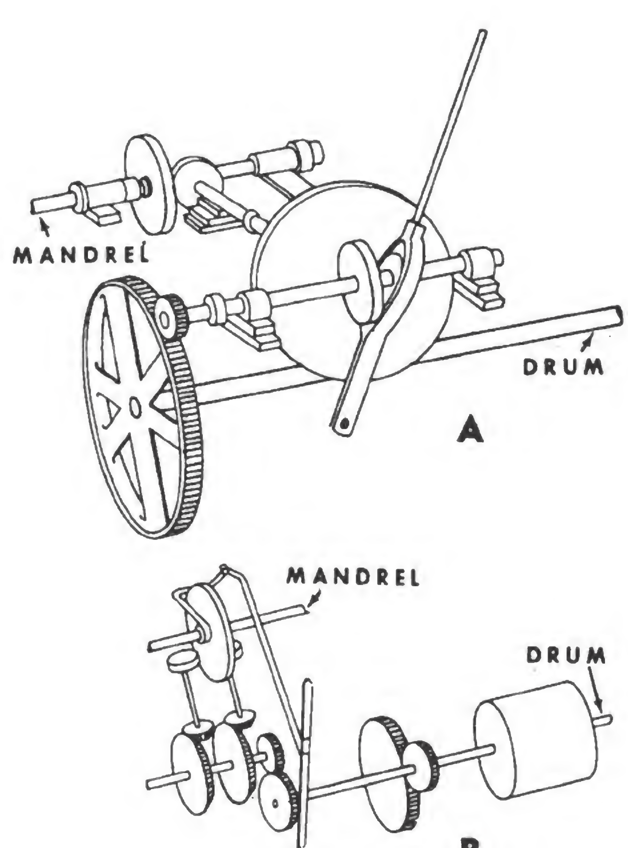
headsaw, are operated by straight friction; friction combined with belts and pulleys; belts and pulleys; belts, pulleys, and clutches; gears and clutches; electrical hydraulic, or steam-piston drives. All may use the cable-over-drum or rack-and-pinion drives.

In STRAIGHT FRICTION types of feed works, beveled plates powered by the mandrel operate a beveled friction wheel and shaft and rotate a disk continuously. By bringing the rim of a lever-actuated friction wheel into contact with this disk, motion is transmitted through shafts and gears to turn the drum and move the carriage. Reverse motion is obtained either by crossing the disk center with the friction wheel contact (A, fig. 7-5) or by contacting the reverse face of the disk with a second friction wheel after breaking contact with the first one (B, fig. 7-5).

In types of feed works employing FRICTION WITH BELTS AND PULLEYS, power is transmitted in one of three ways: (1) from a pulley or sprocket fixed to the mandrel through a belt or chain to a pulley or sprocket shafted to a friction wheel that is lever-actuated to contact a bull pulley shafted directly to the drum (A, fig. 7-6); (2) from the drive pulley on the mandrel by belt to an intermediate pulley, which is shafted to a sprocket transmitting power through the chain to the drum shaft (B, fig. 7-6); or (3) from the drive pulley on the mandrel by belt to a second pulley equipped with an enlarged hub and wide rim (C, fig. 7-6). A friction pulley is placed between the hub and rim (C, fig. 7-6) on a movable shaft connected to the drum, and feed action results from engaging the hub face while gig action results from engaging the inside of the rim. Both feed and gigback can be obtained by the feed works shown in D, figure 7-6.

With feed works that employ BELTS AND PULLEYS, the power for feeding the carriage is transmitted by belt from a pulley fixed to the mandrel to a lever-actuated movable pulley ahead of the mandrel, and thence through a fixed pulley behind the mandrel and the fixed pulley on the drum shaft. Power for reverse motion is transmitted by belt from a second pulley fixed to the mandrel to a second pulley fixed to the drum shaft. A lever-actuated rider is so adjusted in a rocker arm frame that one belt can be tightened and the other loosened by moving the lever to feed or gig position, as desired (see fig. 7-7).

The type of feed works employing BELTS, PULLEYS, AND A CLUTCH has the same hook-

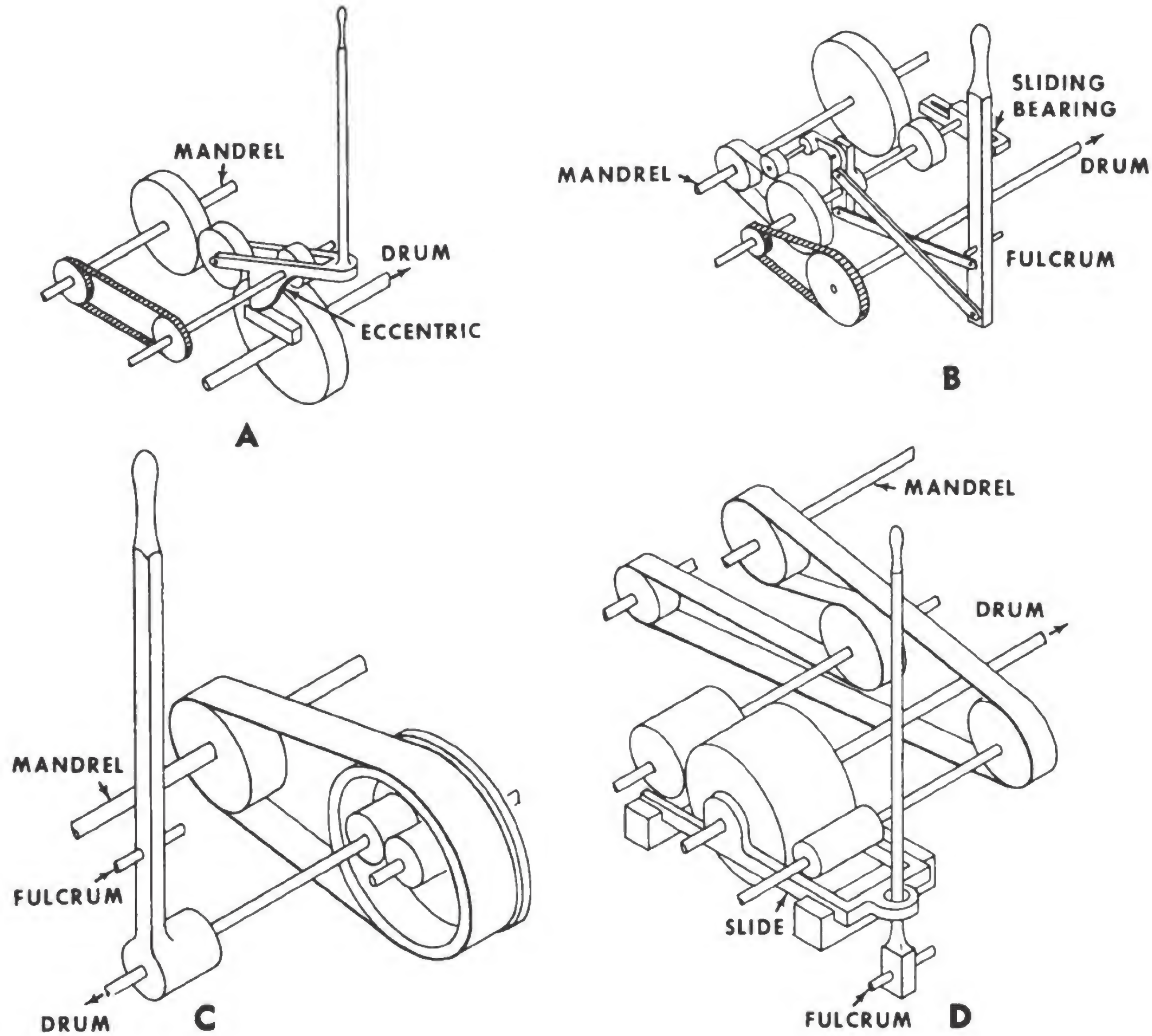


117.232
Figure 7-5. — Straight friction types of feed works.

up as the type with belts and pulleys alone. However, the belts are tight in order to rotate the two pulleys continuously on bearings about the drum shaft or a shaft geared to the drum shaft. Drive or gig is provided by contacting one disk or the other fixed to each of these pulleys with a corresponding disk fixed to lever-actuated pulleys sliding along a key seat on the drum shaft (fig. 7-8).

In the type of feed works operated with GEARS AND CLUTCH, power taken from the mandrel through chain sprockets drives a floating axle and, by means of planetary gears and a drum-brake mechanism, turns the drum shaft (fig. 7-9).

In ELECTRICALLY POWERED FEEDS, the drum is usually installed near the deck end of the track and a reversible direct current motor is connected to it. Rod connection from the sawyer's



117.233
Figure 7-6.— Friction-belt-pulley feed works.

lever to the transformer controls the direction of rotation and speed attained by the motor.

HYDRAULIC FEEDS employ at least three variations in power transmissions: the turbine, the oil motor, and the single-piston.

In the TURBINE, oil under pressure from power usually taken off the mandrel is forced through the turbine blades, thus turning a shaft connected to the drum.

In the OIL MOTOR, a series of small pistons are radially placed on a rotating cylinder that is concentric with a fixed core that contains oil ducts. The piston heads are contained by an outer ring placed eccentrically to the core and free to turn on its axis. The inlet oil vents are so placed that oil under pressure is simultaneously forced into several consecutive pistons during one-half of a complete cycle of the cylinder, and withdrawn during the other half of the cycle.

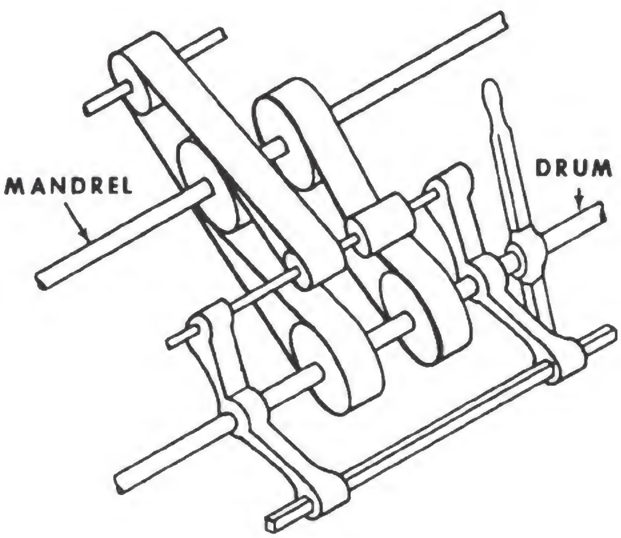


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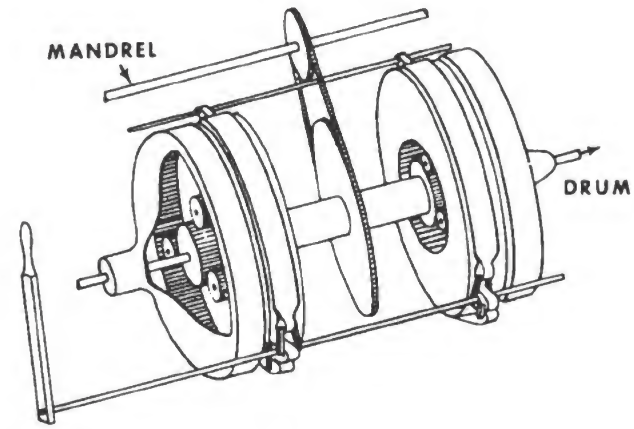
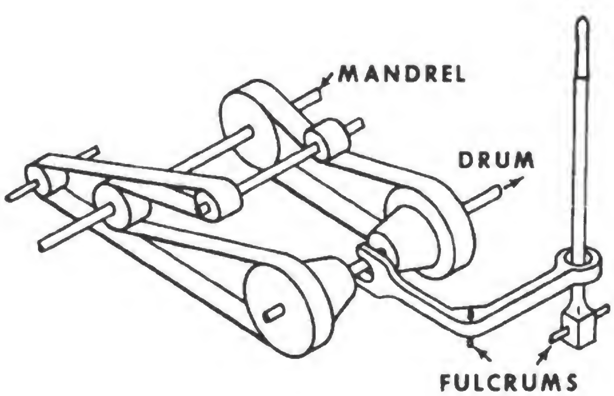
Figure 7-7.—Belt-pulley feed works.



117.236
Figure 7-9.—Chain-driven feed works with lever-controlled brake bevels on split housing.

Oil is closed from the circuit during the longest and shortest phases of the piston stroke.

In the SINGLE-PISTON variant of the hydraulic feed, a cylinder having a length approximately one-half the distance of carriage travel is anchored between the rails. One end of a cable is attached to the cylinder mount (point a, figure 7-10). The cable is brought over one pulley of a double sheave attached to the end of the piston rod and over a second sheave anchored at the deck end of the track, and thence fixed to the front end of the carriage frame (point b, figure 7-10). One end of a second cable is anchored at the opposite end of the trackway (point c, fig. 7-10), passes over the other pulley of the double sheave fixed to the end of the piston rod, thence over a sheave anchored at the nondeck end of the trackway, and is fixed to the back end of the carriage frame. By this means, the carriage travels twice the distance represented by the movement of the piston.



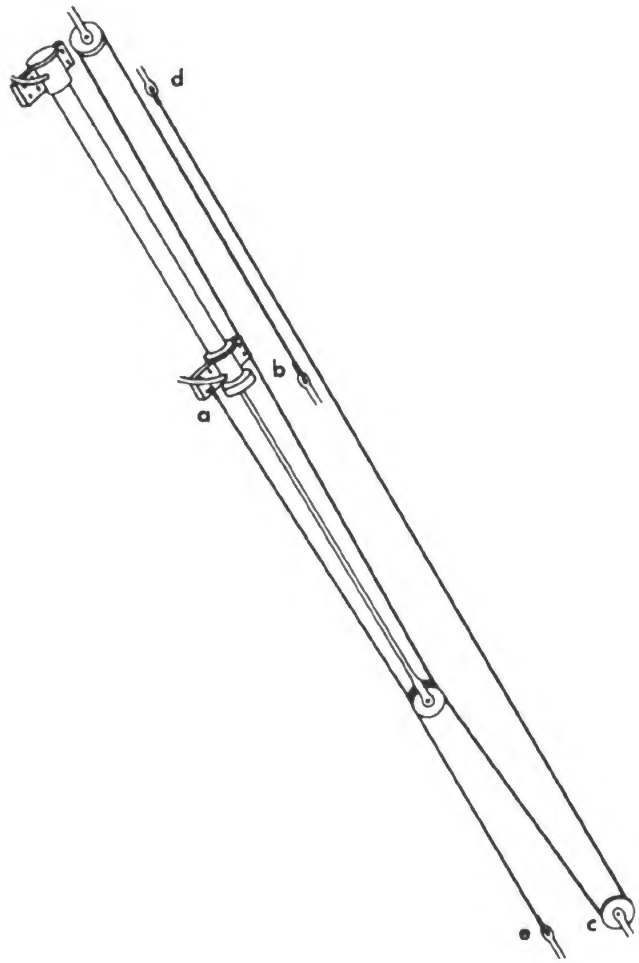
117.235
Figure 7-8.—Belt-driven feed works with clutch.

In one feed system driven by STEAM PISTONS, the TWIN-ENGINE FEED, piston heads in two short cylinders deliver power through connecting rods to turn a crankshaft directly connected or geared to the drum (fig. 7-11). In another system, the SHOTGUN FEED, a piston head in a single cylinder that extends the full distance the carriage travels, is connected by a piston rod directly to the carriage (fig. 7-12).

In the twin-engine feed, a lever controls the direction of rotation and size of valve opening. In the shotgun feed, the lever controls the intake and exhaust at each end of the cylinder so as to apply steam pressure to either face of the piston head and thereby advance or reverse the carriage.

OPERATING FEATURES OF FEED WORKS

In all except the steam piston, electric, and hydraulic types, the feed works is geared to recede the carriage about twice as fast as to advance it. On all types, the sawyer seeks to



117.237
Figure 7-10.— Hydraulic feed works.

adjust the rate of advance to the load capacity of the saw or power source.

The rope-drive and single-cylinder feeds (hydraulic or steam) have the advantage that they can be centered on the carriage, thus minimizing strains in the frame. The rope-drive can be extended more readily to saw long logs than can the single-cylinder variant. The rack-and-pinion drive, applying the propelling force along the edge of the carriage, is more subject to racking, and the carriage travel is limited by the length of the rack fixed to it. This drive, therefore, is less suited to cutting long logs.

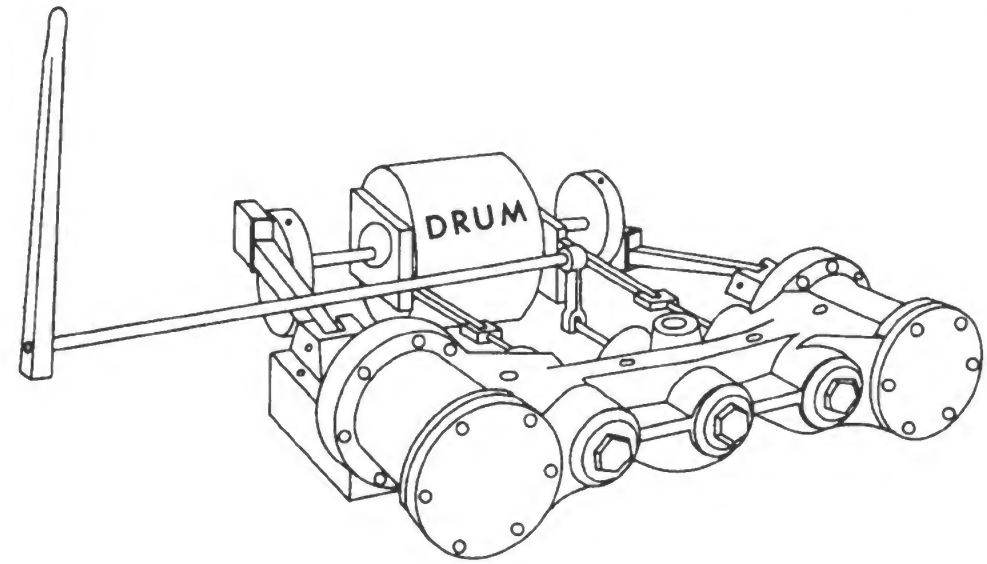
In the straight friction mechanism, the braking action and power transmission are dependent upon the friction where the wheel and disk are tangent. Considerable leverage must be used, and the carriage is braked into reverse by holding the friction wheel in static contact with the moving disk, thus tending to wear flat spots in the friction wheel. Carriage reverse is normally sluggish. In the belt- and pulley-type, braking action and power transmission are dependent on the contact of belt and pulley over areas approximating one-half the circumference of the pulley; consequently, wear is dispersed over a greater area, and a quicker response to the lever is possible. In the type employing friction, belts, and pulleys, the continuously rotating friction wheels tend to wear more uniformly and exert a quicker response than in the straight friction type. The type using belts, pulleys, and clutch and the planetary-gear type exert a quicker response and action than does the type using friction, belts, and pulleys; moreover, they can be used where steam is not available, and are suited to mills producing 2,000 board feet or more per hour.

Steam piston, electric, and hydraulic types combine speed with excellent control, and are used on mills with a capacity of 2,000 board feet or more per hour.

DOGS

Dogs are used to hold the log firmly on the carriage. They employ either a spike or a hook to grip the log. The basic types are those using a fixed post with the spike attached or revolving about it; those with a sliding post; the hammer dog with spike arm and hammer moving through a fixed arc; and the "boss" dog with lever-actuated hooks thrusting out from the knees.

Included in the FIXED-POST, manually operated types are those shown in figure 7-13. The rack variation (A, fig. 7-13) consists of the spike and pinion wheel fixed to the dog housing and the rack machined or stamped into the fixed post. Pawls engaging the rack help keep the spike embedded as the pinion is turned when the lever is pulled down. The dog shown in B, figure 7-13 employs an eccentric to hold the housing to the post. In the threader post or screw dog (C, fig. 7-13), the hooks are fastened to a housing threaded to the post; pawls hold the housing in place or can be withdrawn to permit rapid lifting or lowering of the housing. By turning the fixed post, the dog is raised or lowered as desired. The type of dog shown in D, figure 7-13 consists of a spike at each end of unequal length lever arms that can be rotated around the post. This dog is used mainly to provide additional dogging for large logs. The

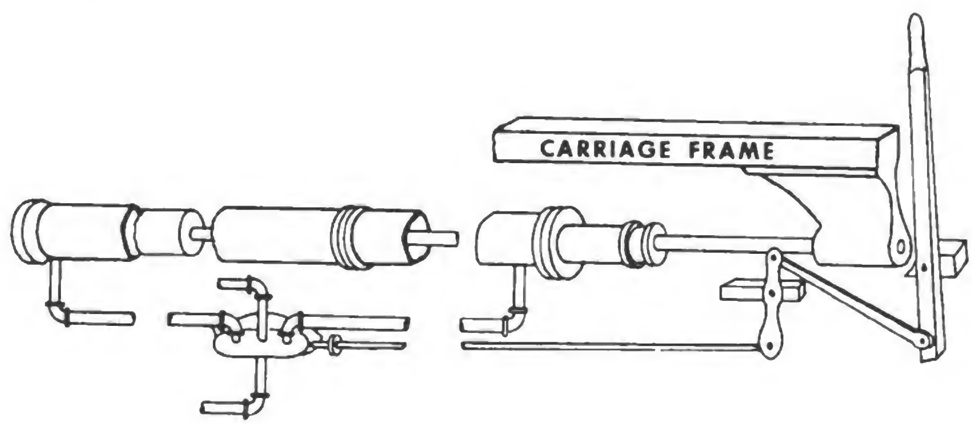


117.238
Figure 7-11.—Two-cylinder steam feed works.

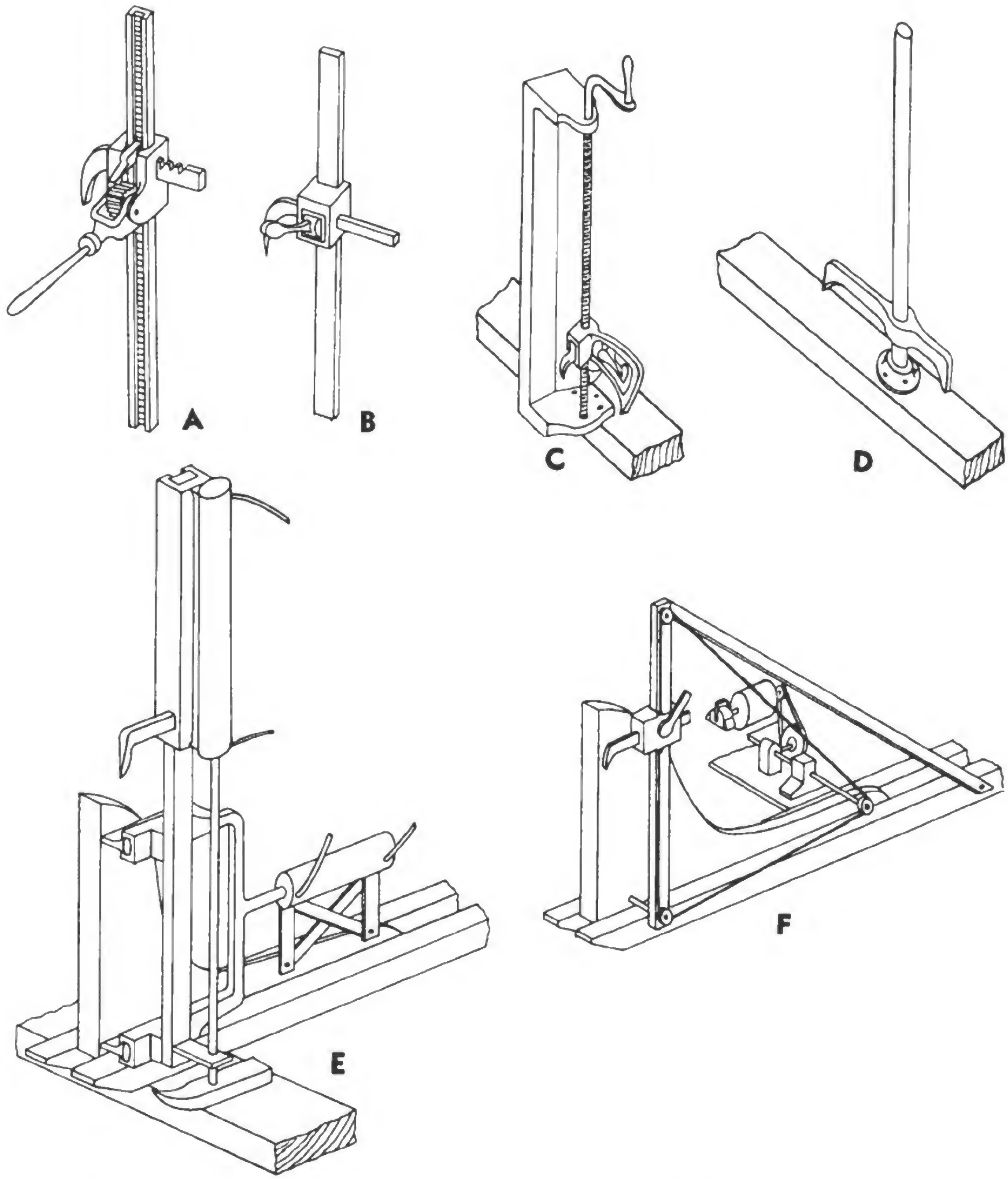
weight of the dog is relied on to clinch the log properly.

Fixed-post, power-operated dogs are actuated by air or hydraulic cylinders and electric motors. The air or hydraulic dog (E, fig. 7-13) consists of a cylinder fixed to the spike housing with the piston rod anchored to the base of the dog. When the cylinder is actuated it pulls the dog into the log. The electric dogs have a chain attached to the top and bottom of the spike housing, and thence over sprockets propelled by the motor (F, fig. 7-13). Provision to break the current at a definite load prevents strains on the assembly.

MOVING-POST types of dogs are shown in figure 7-14. A down pull on the lever gives a downward movement of the spike, and in those illustrated in C, D, and E of figure 7-14 a simultaneous upward movement of the bottom dog. In variant of the screw dog (F, fig. 7-14) the sliding bar movement results from threading it to the fixed screw shaft.

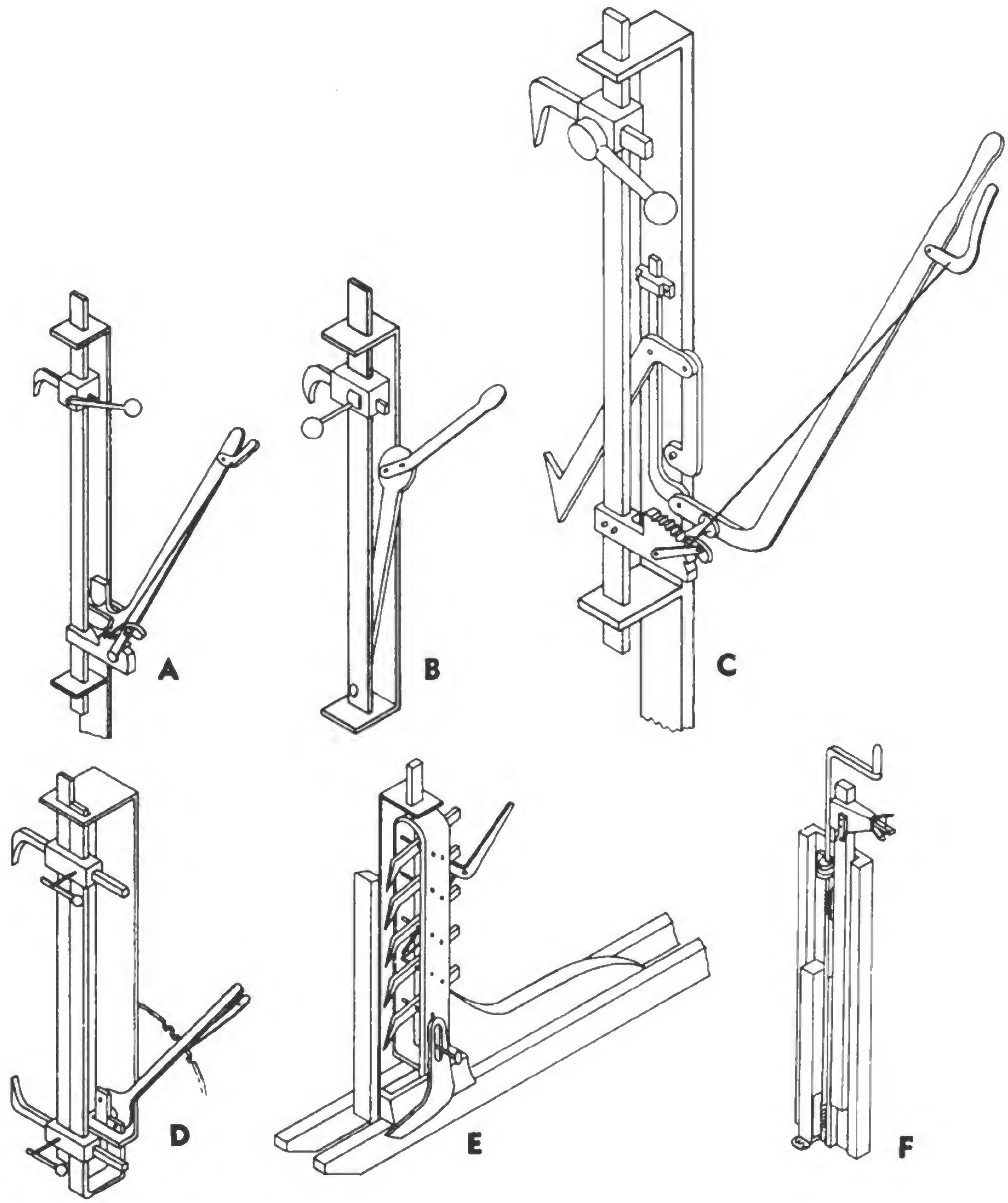


117.239
Figure 7-12.—Single-cylinder steam piston feed works.



A. Rack-Post
B. Eccentric-Lock
C. Threaded Post
D. Rotating-Spike
E. Air or Hydraulic
F. Electric

117.240
Figure 7-13.— Fixed-post types of manually operated dogs.

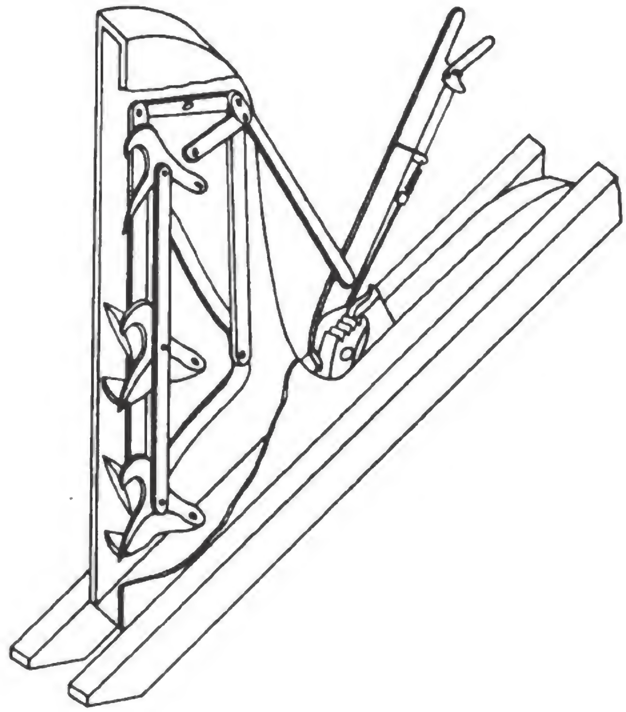


A. Single-Bar Single Dog, Lever at Base
B. Single-Bar Single Dog, Lever at Midpoint
C. Single-Bar Top and Bottom Dog
D. Double-Bar Top and Bottom Dog
E. Yoked Bar, Dog with Pivoted Top and Rotating Bottom Dog
F. Double-Bar Threaded-Post Dog

117.241
Figure 7-14.—Housing-post types of manually operated dogs.

The HAMMER DOG (fig. 7-15) is at the end of a radial arm, the opposite end being fixed to the knee. The hammer and lever are also pivoted at the same point, the hammer following the arc of the spike as the lever is raised. This dog is intended to provide additional dogging on large logs when making the first cuts.

The "BOSS" dog (fig. 7-16) consists of a series of levers and fulcrums that synchronize the upward and outward thrust of one set of hooks with the downward and outward thrust of another set as the lever is pulled down.

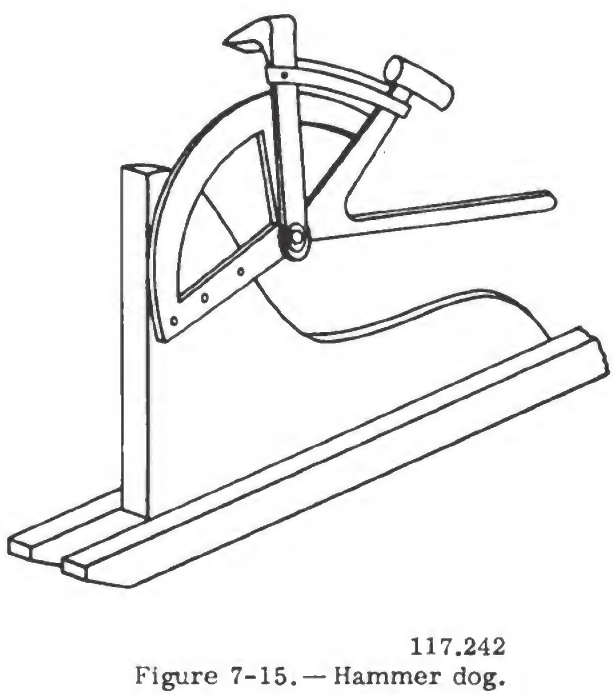


117.243
Figure 7-16.—"Boss" dog.

SETWORKS AND RECEDERS

The function of the setworks is to advance the log quickly toward the saw line by intervals accurately held to the thickness being cut, and to reverse the knees speedily. Precision in reversing is not vital. The mechanism by which the knees of small mills are advanced may be lever-operated or power-operated. They may be receded by lever, by springs, or by power-actuated devices.

To advance the knees in LEVER-OPERATED EQUIPMENT, the toothed rim of the set wheel fixed to the set shaft is engaged by pawls attached to the lever (fig. 7-17). A pull on the lever is transmitted as a turn on the set shaft to the pinion wheel fixed to the shaft at each knee.



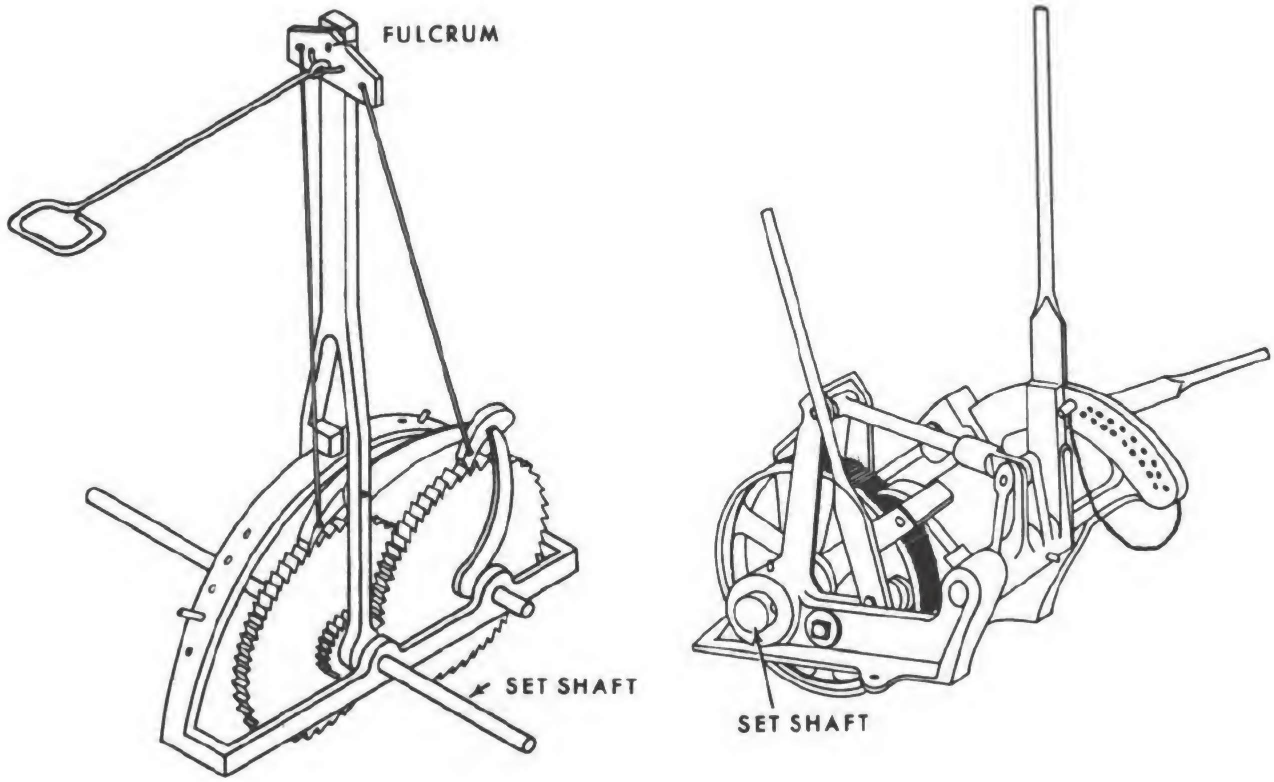
117.242
Figure 7-15.—Hammer dog.

The pinion turns in the rack of the fixed bolster, and advances the knee. With single-acting levers, the knees are advanced by forward lever movement only (A, fig. 7-17). With the double-acting type (B, fig. 7-17), knees are advanced on the back stroke as well, through a second set of pinions or pawls below the fulcrum of the lever arm.

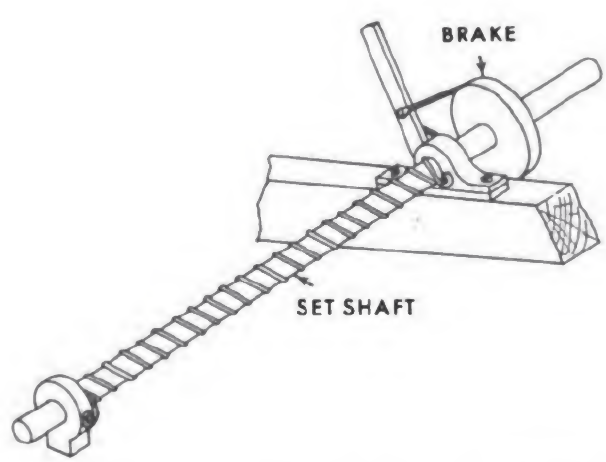
In SPRING-ACTUATED RECEDERS (fig. 7-18), a spring coiled about the set shaft has one end anchored to a collar fixed to the set shaft, and the other end anchored to the frame of the setworks. It is so oriented that, as the set shaft is turned in advancing the knees, the spring is tightened.

POWER-ACTUATED RECEDERS vary widely in design. Knees may be moved by means of power taken from movable beams, chains, ropes, drums, electric motors, or hydraulic pistons.

A common power source is an elevated BEAM alongside the track that rotates a wheel fixed to a shaft having a set of bevel gears connecting with the set shaft (see A, fig. 7-19). As the carriage is gigged back, the sawyer steps on the foot lever and the knees are receded. Another



117.244
Figure 7-17.—Lever-actuated setworks.

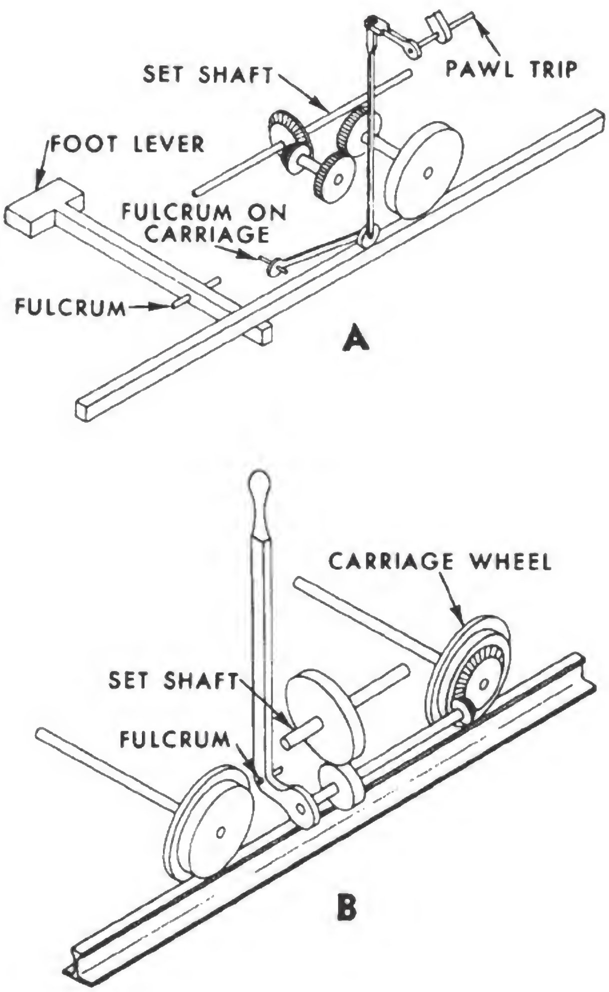


117.245
Figure 7-18.—Spring-actuated receder.

source (B, fig. 7-19) takes power from a carriage truck wheel to turn the set shaft.

In the CHAIN type of power setworks and receder, both setting and receding are done by meshing a sawyer-operated foot lever to a power-driven sprocket anchored inside the track. The sprocket engages a chain drive on the carriage that is connected to bevel gears that actuate the set shaft (fig. 7-20).

In ROPE-ACTUATED types, the rope may be stationary or a continuously running belt. The stationary system (fig. 7-21) consists of a heavy manila rope extending the full track length about 5 feet above the outside track-way and passing over one and under another grooved pulley of the setworks mechanism anchored on the carriage. When the rope is held tight by the sawyer, as the carriage is advanced or gigged back, the headblocks are advanced or receded. With the continuously running system, the rope, powered by an electric motor, is run over a grooved pulley at each end of the carriage track and



117.246
Figure 7-19.—Power receders.

returned below these pulleys. A friction wheel is placed on the shafts of both pulleys of the mechanism attached to the carriage. The knees are advanced or receded when one or the other friction wheel is brought against the disk by tilting the frame with a lever.

The DRUM-ACTUATED type (fig. 7-22) consists of a constantly revolving cylinder that can be moved laterally by means of a lever operated by the sawyer. Two friction wheels are fixed to the under side of the carriage so that either way may be in contact with the revolving cylinder which engages one friction wheel to advance or the other to recede the knees. The friction wheels are connected by belts or gears to the set shaft.

In the type of setworks and receder actuated by an ELECTRIC MOTOR, a reversible motor is connected through a gear train to the set shaft. Power is supplied to the motor when the knees are to be advanced or receded.

HYDRAULIC setworks may be of two types. In one type, a hydraulic turbine is connected to the set shaft through a gear train. By operating the turbine in the forward or reverse direction the knees are either advanced or receded. In the other type, hydraulic cylinders are connected to the set shaft with a rack and pinion gear train. As pressure is applied to the cylinder the piston is extended and the set shaft is rotated.

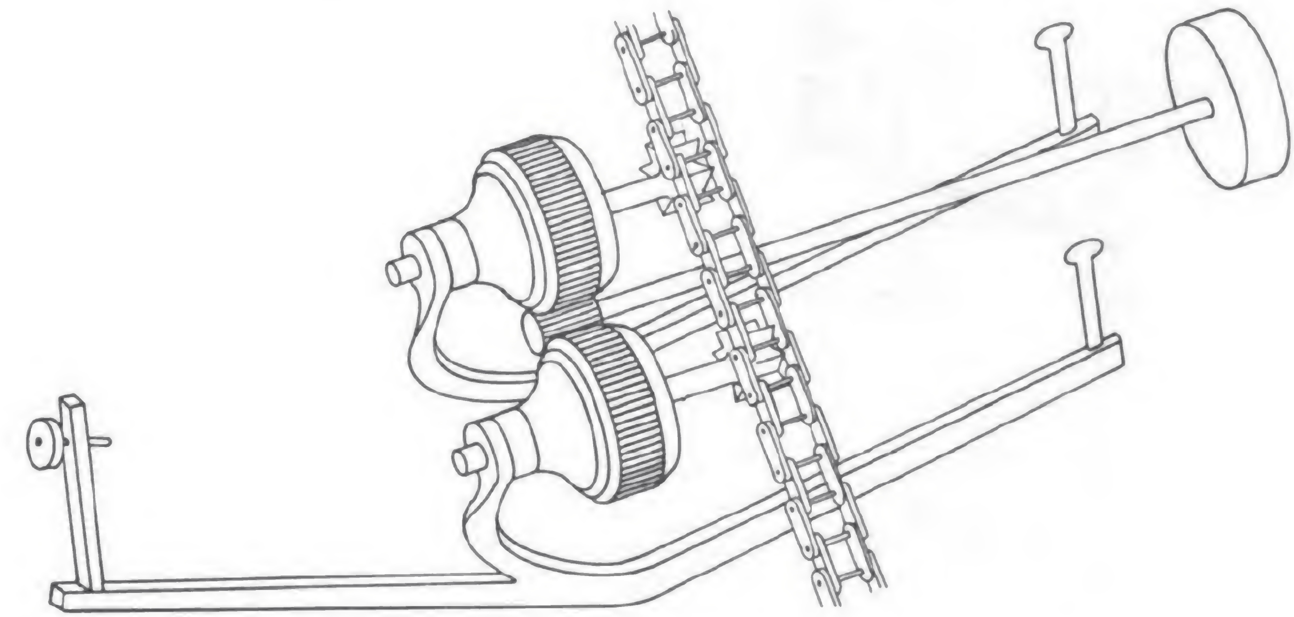
INDICATORS

Most types of setworks have indicators to show the distance between the face of the knee and the saw line. Some, in addition, indicate the number of boards of a given thickness that can be taken by sawing through the cant (A and B, fig. 7-23). The type having numbers and pointer on the bolster and knees (fig. 7-24) is least satisfactory because of poor visibility and the difficulty of quickly centering the pointer on the desired mark. A vertical gage board in sawyer-operated setworks, or a wheel gage where the sawyer rides the carriage, is easier to read and can guide the sawyer after the final turning to utilize the cant fully.

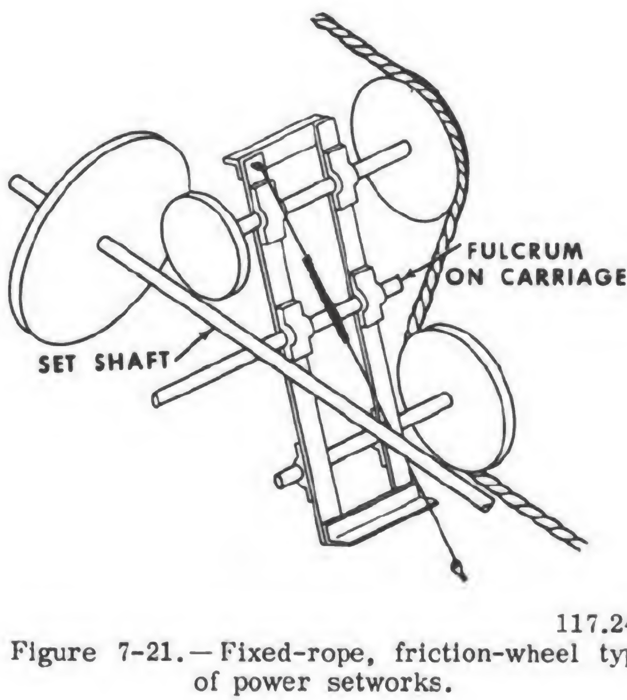
LOG TURNERS

Small mills operating in small timber find log turners of little practical value. An experienced deckman with a short-handled cant hook can turn logs under 20 inches in diameter as quickly as can power turners, and with less shock to the carriage. They are rarely used in really portable mills, but are practical in semipermanent sets cutting large logs. Types of log turners used on small mills include the slip-block or the hinged-block; the overhead; the friction; and the rocker-arm type.

The slip-block mechanism is useful in turning medium and large logs because it lessens the shocks to equipment and the physical work of placing the log. It turns the log toward the deck. The overhead type is practical where large logs must be handled, being durable and faster than cant hooks. The friction and rocker-arm types must be kept in accurate adjustment, and be backed up by heavy carriages and trackways;



117.247
Figure 7-20.—Power-actuated setworks.



117.248
Figure 7-21.—Fixed-rope, friction-wheel type of power setworks.

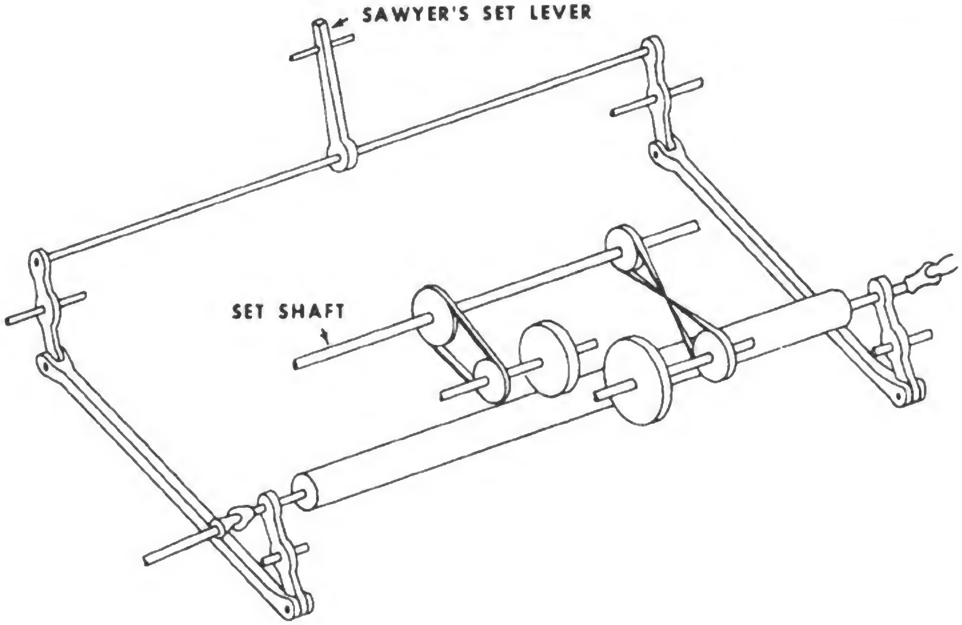
they require a pit or elevated mill and a sturdy carriage.

ROLLS AND SPREADERS

Standard equipment on most circular mills is a roll or bar attached to the husk ahead of the saw and a spreader and roller immediately back of the saw. The bar steadies the slabbed log (cant) and expedites its passage into the saw; the spreader and roller keep the board from binding the saw and expedite its passage. Usually, spreaders are disks that are flat on the log-side face and beveled to a thin edge from the board-side face. Many operators replace this disk with a spreader shaped like a scythe blade and curved to parallel the perimeter of the saw.

EDGERS

There are three types of edgers used by small mills. A single-saw type usually employs a light flatcar pushed along a trackway to carry the board through the saw one edge at a time. In the type having two or more saws on a single mandrel, the boards are fed through the saws



117.249
Figure 7-22. — Drum-actuated setworks.

by power rolls and one or both sides are edged or ripped for grade and size requirements. The vertical-edger type, with two or more saws on a vertical mandrel, is installed ahead of the headsaw to edge the boards as the carriage carries the log through the saw.

The SINGLE-SAW carriage edger carries a saw 14 to 16 inches in diameter running approximately 2,000 revolutions per minute on a mandrel about 1-1/2 inches in diameter. The carriage is a platform about 14 feet long and 2 feet wide mounted on trucks, the flanged wheels of which run over a flattopped track.

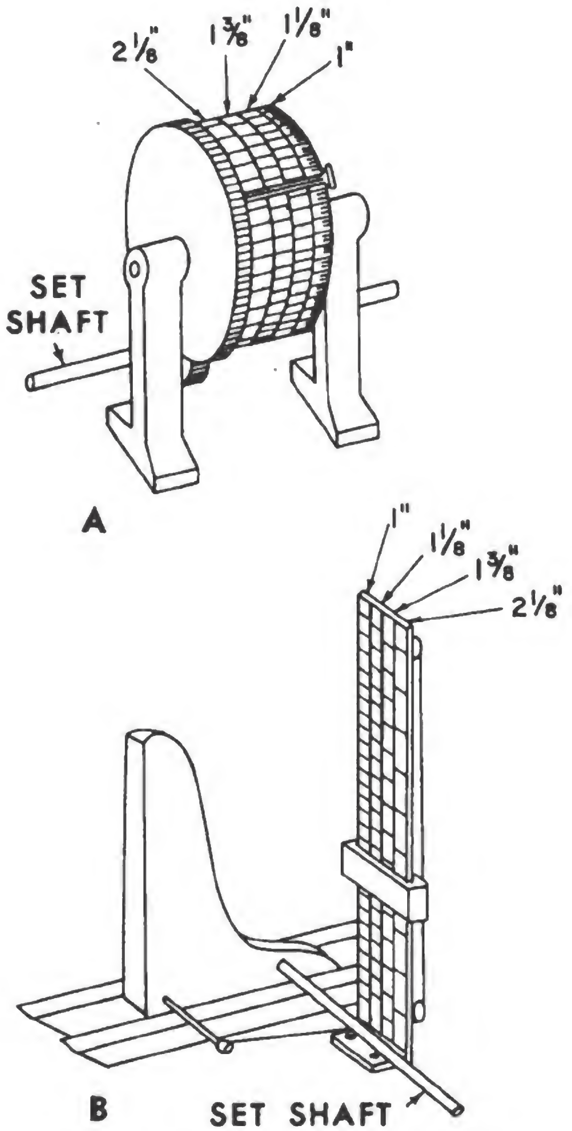
In the MULTIPLE-SAW type of edger, all saws may be movable along the mandrel, or one may be fixed and the others movable. The fixed saw is usually attached to the mandrel about 6 inches from one edge of the feed bed. A movable guide on the feed bed can be placed so that any width edge can be taken up to the full 6 inches. The movable saws slide along two keys to opposite sides of the mandrel. Each saw is connected, by means of a fork engaging opposite sides of the collar or guides on the saw, to a lever arm extending to the front of the machine and fulcruming at about its midpoint. An indicator is fixed to the lever arm just ahead of either the saws or the feed table and guides the operator in spacing the saws. Notches or holes in the frame, together with pawls or pegs on the lever arm, hold the saw in the position required. The board is fed through the saws by means of top and bottom powered feed rolls, one pair just ahead of and another behind the saws.

VERTICAL EDGERS are mounted on a specially built metal husk frame in such a way that the perimeter of each horizontally mounted saw exactly reaches the log side of the headsaw cutting plane at a line about 2 feet ahead of the headsaw. Thus, as the carriage is advanced the edger saws the edge to the thickness set. The bottom saw may be fixed to the vertical shaft, or all saws may be movable up and down the shaft by means of levers or hydraulic pistons manipulated by the tail sawyer.

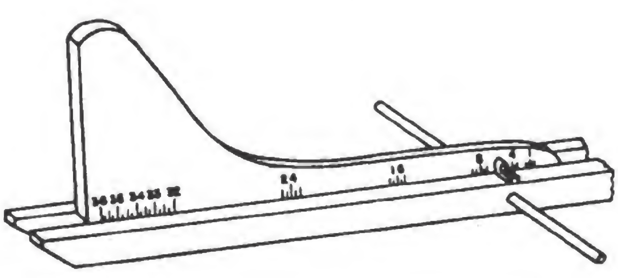
TRIM AND CUTOFF SAWS

Types of trim saws used on small mills are the single cutoff, the two- or three-saw cutoff, and the battery trimmer.

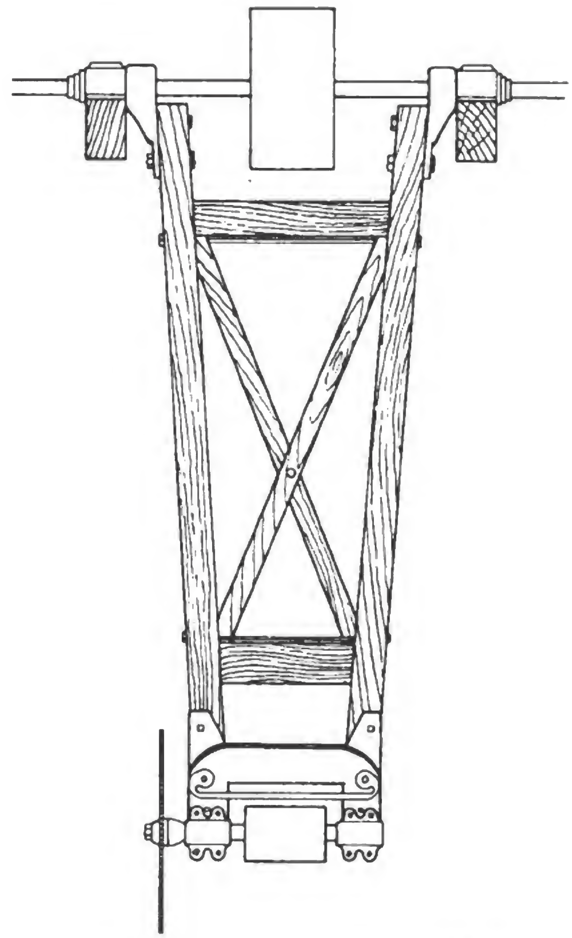
The SINGLE CUTOFF SAW (fig. 7-25) consists of a swinging frame pivoted to bring the saw



117.250
Figure 7-23.—Types of indicators.



117.251
Figure 7-24.—Indicator on bolster and knees.



117.252
Figure 7-25.—Single cutoff trim saw.

across the flow line of the material. The frame normally rests so that the saw is within a guard clear of the flow line. Trimming is done by pulling the saw across the material. The pivot can be above or below the flow line. If its function is mainly to make boilerroom fuel, it may be located opposite the tail sawyer-edgerman, who pulls slabs across the edger feed table and segments them with or without assistance. If its function is mainly to cut up slabs for fuel or to trim ties and timber, it is usually located near the back end of the edger in the rolls from the headsaw. If the main function is to trim boards, it is usually near the back end of the edger across from these rolls. The larger sizes take a saw up to 42 inches in diameter, but saw diameters normally are 24 to 30 inches.

The standard TWO-SAW TRIMMER consists of two (or, rarely, three) saws on a single mandrel.

The saws are movable along the mandrel, their spacing being controlled with a crank or wheel to permit trimming a variety of lengths. In hand-feed trimmers the material is placed in front of a movable straightedge guide and pushed through the trim saws. In the power-feed type, moving chains with lugs carry the boards through the trim saws. In some models, the saw-spacing crank or wheel is attached to a movable transfer block; in others, it is fixed to the frame. The thickness of the stock trimmed depends upon the saw diameter; 16-inch saws take 3 inches, 20-inch saws 5 inches. Saws run at a rim speed of 94,000 feet per minute, and the feed rate is gaged at 30 or 50 feet per minute.

The BATTERY TRIMMER is the small-mill adaptation of the multiple-saw trimmer used on larger mills. Four or more saws, each on a separate mandrel and each in a pivoted frame comparable to that of the single cutoff saw, are placed in line across the line of flow material. The operator, through lever action, can extend a selected saw to cut a given length, the remaining saws being retracted either above or below the line of flow of the material.

MILITARY SAWMILL EQUIPMENT

Sawmill equipment used at Seabee activities includes the trailer-mounted and the portable type of sawmill.

The TRAILER-MOUNTED sawmill commonly used today is constructed of steel tubing with a main frame assembly of steel tubes welded to form trusses. It is mounted on a single axle fitted with wheels having 9.00- x 16-inch pneumatic tires. The sawmill is designed to use a saw of 50-inch diameter. The sawmill will produce a minimum of 1,000 board feet of 1-inch lumber 12 feet long per hour from softwood. The sawmill will cut both hardwood and softwood logs. The carriage is mounted on rollers and is power-moved along the rails by rope feed.

The PORTABLE sawmill frequently used is designed to saw rough lumber from softwood and hardwood logs at a rate of 10,000 to 30,000 board feet of lumber per day. It is powered by a diesel engine which also powers a hydraulic motor attached to a wire rope drum which moves the carriage past the saw.

SAWMILL CREW MEMBERS AND DUTIES

The milling and yard section personnel may be required to work in the log yard, on the sawmill, and in the lumberyard. The duties of crew members described in following sections are suited to an ideal mill operation. Variable local factors will necessarily change this plan.

PORTABLE SAWMILL CREW

A suggested crew for the portable sawmill consists of 14 to 16 men, depending upon local conditions. When large, uneven logs are being handled, additional men will be needed on the log skids. With small- or medium-sized straight logs, one man can usually handle the log skids. Two to four men are required to take the lumber from the edger and cutoff rig, depending upon the sizes of lumber and the distance to the yard.

The sawyer is usually the sawmill foreman and is responsible for the crew's safety as well as for production.

The block setter works closely with the sawyer. He operates the setwork and also the dogs on the front headlock.

The dogger operates the dog levers on the center and rear headblock knees.

The log-skid man keeps a supply of logs ready to be rolled onto the headblock bases. He also holds the log against the headblock knees when the log is being secured to the knees. If logs are heavy or crooked, one or two extra men may be needed on the log skids.

The off-bearer is stationed at the tail of the headsaw to handle boards sawed from the log. In most cases the off-bearer rolls the board on the lumber rolls to the edger man. If boards do not require edging, the off-bearer passes the board along the lumber rolls to the cutoff rig.

The edger man operates the edger to remove the bark edges or defective edges from the board.

The edger tailer man removes the board, strip, end, and bark edges from the edger rear table. If a board requires end trimming, the edger tailer man passes the board along the lumber rolls to the cutoff operator at the cutoff rig.

The cutoff operator operates the cutoff rig to square off the uneven ends of the boards.

Two or three lumber stackers are needed to carry the lumber from the edger or cutoff rig to the yard.

The refuse man keeps the cutoff rig and edger free from accumulation of strips, slabs, knots, and ends. He also keeps sawdust from accumulating in the dust holes under the edger and cutoff rig.

The millwright is responsible for keeping belts, accessories, tools, and spare saws in good operating condition. He continually checks the power unit engines and cutoff engine for satisfactory operation. The millwright and his assistant help replace saws and check the installation.

The millwright assistant helps the millwright in the duties outlined in the above paragraph. The assistant also keeps fuel tanks and radiators filled as required.

TRAILER-MOUNTED SAWMILL CREW

The minimum crew size for the trailer-mounted sawmill is five men: a sawyer, two log deckmen, and two off-bearers. Their duties and responsibilities are the same as described above for a portable sawmill crew.

COORDINATION OF SAWMILL CREW

For effective sawmill operation, each crew member must understand his duties. He must have sufficient training to work efficiently with other crew members. It is especially important that the sawyer and block setter work closely together when scaling logs, preparing for cuts, and making cuts. Working as a team, the sawyer and block setter will soon adopt a few simple operating signals for figuring, turning, and sawing the log.

YARD CREW

The yard crew responsibilities will depend upon the type of operation taking place. If lumber is not being stacked and dried but is being shipped as soon as it is sawed, three or four yard workers can keep the lumber moving onto the lumber-hauling trucks. If the lumber must be stacked and stored, then the size of the crew should be increased to handle both stacking and shipping.

SAWING PROCEDURES

The most advantageous method of sawing logs on any operation depends upon the demand for different grades and the thickness desired within a grade. Thick stock of the better grades is normally more desirable than inch lumber. In hardwoods (graded from the poor face) the likelihood that the grade on the inside face will hold up to that on the outside decreases as thickness increases; hence, to capitalize on thick stock requires expert knowledge by the sawyer.

The sawyer must know the following details of lumber grading:

1. The minimum width and length provisions of each grade, as a guide when slabbing.
2. The defect allowance of clear-face requirements of the grade, as a guide in log turning.
3. The grade provisions applying to the lowest desirable grade, in order to avoid wasting time or making undesirable stock.

The edger operator must know:

1. The minimum width-length provisions of each grade.
2. The amount of permissible wane. (The term wane refers to the bark or lack of bark, or decrease in wood from any cause on the edges of board, plank, or timber.)
3. The provisions covering standards of manufacture, particularly that applying to crook.

Both the sawyer and the edger operator should take into consideration the minimum thickness, width, and length provisions of the grade rules that apply to dry lumber. They must also allow for shrinkage in thickness and width in cutting green lumber. Hardwoods are edged to give the widest possible board in any fraction of inches above the minimum required. Softwoods are sized to give widths in 1- or 2-inch intervals.

Recommendations applicable to milling both softwood and hardwood logs are:

1. Clear faces should be taper-sawed in order to get the maximum possible footage in upper grades.
2. Thin stock should be taken next to the slab to minimize edging waste.
3. The pith should be enclosed within a boxed heart item where splits and checks are not considered a degrade.

MILLING SOFTWOOD LOGS

To minimize waste, boards of different sizes should be made, the particular sizes being varied

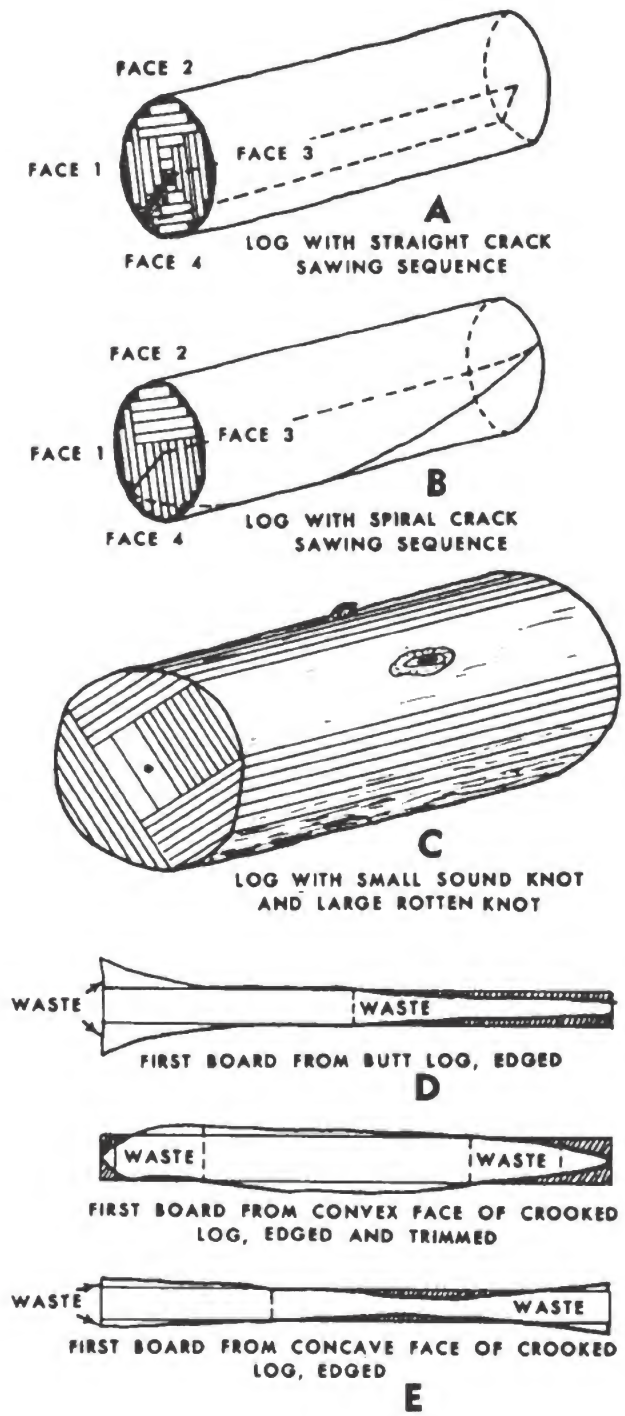
according to the log. In this way complete utilization is most nearly attained. It is also desirable to saw the log in such a way as to produce lumber of maximum grade values.

The size and grade standards for desirable items are given in grading rules and a sawyer should master these provisions for the species sawed. Normally, however, there is a greater demand for certain sizes or grades than for others. The effect of this is to limit the size combinations that can be used. For instance, the nominal widths specified under softwood rules include each inch class from 3 to 12 inches, but a need rarely exists for widths of 7, 9, and 11 inches. Likewise, for some softwood species, No. 1 common boards are in little demand, whereas No. 1 common dimension is readily utilized. Since softwood is graded from the best face, usually the sawyer can estimate the approximate grade before setting is done and readily substitute dimension for boards.

The several methods of sawing softwood logs differ mainly in the sequence used in turning. The two objectives of a sawyer are to recover maximum grade values and get maximum volume production per hour. It is not possible to get both by any one method; either the frequent turning required to recover the maximum grade values reduces volume, or the minimum turning necessary to get maximum production sacrifices grade. In order to get a balance between grade values and production volume, turning procedure must be varied in accordance with log qualities, sizes, and mill facilities. No rigid set of instructions can be universally applied. The ones suggested herein are commonly used and provide the beginner with a definite starting point.

The turning sequence (A, fig. 7-26) is easily identified by terming the first log face to be sawed, face 1, after which faces 2, 3, and 4 will be turned in sequence starting from the top and ending with the bottom, face 3 being opposite face 1. Greater production volumes are possible by using the 1-3 sequence; better grades usually result from some combination of 1-2-3-4. This is due to the fact that the best grade of lumber in a log is just under the slab, while the heartwood contains the poorest grade. In the faster 1-3 sequence there will be some heartwood in the majority of boards while in the slower 1-2-3-4 sequence heartwood will appear only in the last few.

In sawing logs, the sequence in which faces can be sawed is limited by the requirement that adjoining sawed faces must be at right angles. To ensure this, the first face sawed must be



117.253
Figure 7-26.—Sawing procedures.

turned to the bolsters or to the knees. On mills equipped with dogs incapable of preventing the log from turning while face 1 is sawed, a slab is taken from face 4 and the log turned so that face 4 rests on the bolsters. In the following instructions it is assumed that the dogs will hold the log firmly; otherwise, the outline procedure must be changed so that face 3 is slabbed and turned to the bolsters before face 1 is worked.

For logs 12 inches or less in diameter and promising only common grades, the 1-3 sequence is used, sawing nearly to the center from face 1 and then turning the log 180° and finishing it. The dog board (the final board) is usually cut to dimension size. If the first face is not worked to near the center of the log, most types of dogs will fail to hold the piece as the opposite face is worked beyond the center.

The first slab should give a face of a minimum desirable width. In slabbing the opposite face, the sawyer adds to the thickness and saw kerfs remaining to be cut and so slabs the piece as to end up with a dog board of proper size. In practice the second face to be cut is brought to the saw line to give a tentative face of minimum width. The sawyer then decides whether a thicker slab is required in order to have a dog board of proper size at the finish.

For logs of common grade quality exceeding 12 inches in diameter, the 1-3 sequence has disadvantages. The edger operator is prone to lose potential footage in the wide center boards through improper ripping. Lumber from rip lines along or near the pith tends to crook in drying. For such logs, a 1-2-3 sequence is recommended if turning is done with cant hooks, or a 1-3-2-4 sequence if powered equipment that turns the log up and over is used. In using the 1-2-3 sequence, faces 1 and 2 are slabbed to give boards of minimum width, and face 3 to end with a dog board of proper size. In the 1-3-2-4 sequence, face 1 is slabbed to give boards of minimum width, face 3 to end with a cant thickness of 6, 8, 10, or 12 inches instead of a dog board, face 2 to give a face of minimum width, and face 4 to give a dog board of proper size as sawing is completed.

A secondary refinement in sawing of common grades is that knots should be toward the center and away from the edges of sawed stock. Thus, so far as possible, the log should be placed on the carriage so that the visible knots will be toward the center of the face rather than at the margin.

The recommended practice for logs promising a portion of their lumber in grades above common is to place the high-grade faces to the saw and taper-saw them (parallel to the bark). If all but one of the faces is clear, the log is placed with the poor face to the saw, slabbed and turned to face 2 on mills employing turndown equipment. Before face 2 is sawed, the small end of the log is set out to get a slabbed face of uniform width and length of the log. After slabbing to a face of minimum width, this face is sawed until the grade drops to common.

The log is next turned to bring face 3 to the saw, which is slabbed and sawed as was face 2. By slabbing face 1 as instructed, face 3 will be taper-sawed without setting out the small end. Next, the log is turned to face 4, the small end set out as for face 2, and this face is sawed until common lumber develops. Before turning to another face the taper is taken out by retracting the taper blocks, bringing the cant (a log that has been slabbed on one or more sides) against the knees, and sawing the wedge so as to have a cant thickness of 6, 8, 10, or 12 inches. If short pieces are usable, one or more short boards are taken in straightening the cant. In order to end up with a dog board of proper size, the sawyer adds the thickness and saw kerfs remaining to be cut and slabs accordingly on the third and fourth faces of the log.

If two adjoining faces are clear, the log is placed so that one poor face is to the saw and the other is up. Face 1 is slabbed and may be sawed lightly, then face 2 is brought to the saw and treated likewise. Faces 3 and 4 are successively taper-sawed deeply without use of taper blocks.

If two opposite faces are clear, the log is placed with a clear face on top. After face 1 is worked as described above, face 2 is brought to the saw, the small end of the log is set out, and this face is worked until common lumber develops. Next, face 3 is sawed as described for face 1. Face 4 is taper-sawed after the small end is set out, and before the cant is turned to another face it is straightened as previously described.

A log with a single clear face is placed on the carriage with this face against the knees, thus permitting the clear face to be taper-sawed without the use of taper blocks. These instructions are for mills employing equipment which turns down logs. For mills turning up, the log is turned either 180° or 270° after face

1 is worked and the procedure modified to conform to this different turning system.

Rough softwood lumber that is to be surfaced, or surfaced and patterned, must be edged and trimmed to widths and lengths that allow for the manufacture of finished lumber of definite size standards. Usually nominal widths are 3, 4, 5, 6, 8, 10, and 12 inches with even-foot lengths. A flitch that can be edged and trimmed to produce a board of 9-inch nominal width and 11-foot length, but cannot be made 10 inches wide by 12 feet long, should normally be sized to 8-inch nominal width and 10-foot length. Since wane is excluded from surfaced or patterned material for most items, edging and trimming should remove wane that will not be surfaced out.

A simple rule to guide the edger operator is that normally material should be edged to get the widest stock possible and in the maximum even-foot length, but that the width should be reduced by 2 inches wherever 4 feet or more can be gained in length. The edger operator thus tentatively estimates the even-foot length for a board of a given maximum width and decides if a width reduction of 2 inches allows for a length extension of 4 or more feet.

The edger operator should have definite instructions on the green width required for each width class manufactured in the mill. Basically these widths depend upon an allowance for shrinkage in drying, usually 1/16 inch per inch of width, and an allowance for planing, usually 1/16 inch per face planed. These allowances are added to the actual width standards set up for yard items by military specifications.

Wide pieces should be ripped into any series of widths that will raise the grade of one board above that of the wide piece. If no grade raise is possible, the piece should be ripped to produce a board 12 inches wide and the others as wide as possible, but normally avoiding 7-, 9-, and 11-inch widths. Where possible, wide pieces should be ripped so as not to intersect a knot that may fall out during seasoning, nor should material be ripped so that the pitch is at the edge.

The trimmer operator trims to produce a desirable board of the maximum even-foot length possible. Usually, a 2-inch allowance in excess of the even-foot length is made when trimming.

MILLING HARDWOOD LOGS

Sawed hardwood is mainly channeled to two outlets—sources using material of random width and length, or construction units which require material of specified size.

The sawing practice for grade-sawing random size hardwood lumber should be to work the high grade material from the better faces by taper-sawing, and then turn to a different face as the grade drops below that promised by adjoining faces. This process of working around the log is usually profitable if it results in raising the grade from No. 1 common to No. 2 common.

As the log is transferred to the carriage, the sawyer should decide how to divide it into four cutting faces and the probable sequence to be followed in sawing them. Deciding on one face automatically fixes the other three. A mirror at the deck end of the track reflecting a view of the end farthest from the sawyer as the log is against the knees is helpful in judging the influence of end defects in determining faces and probable sawing sequence. In the following description, face 1 is to the saw, face 2 on top, face 3 against the knees, and face 4 on the bolster for initial sawing.

For clear, straight, sound logs with the pith as the approximate center it makes no difference how the log is divided into faces, and the cutting sequence from one face to the next is that involving the least delay. Thus, at mills turning down, the cant is turned down 90°. At mills turning up, the cant is turned at least 180° from the first face. If the pith is off center, the log should be placed so that one face is perpendicular to the longest radius.

Logs with a straight crack are placed so that the crack is at the board edge that is to be taken out in edging (A, fig. 7-26). The crack should coincide with the radius that is 45° to the bolster and toward the saw. If, however, face 2 promises high-quality material and hence, should be taper-sawed, a slab is taken from face 4 before turning to face 1. This high-quality face 2 is taper-sawed as described so that a board of minimum useful width can be taken the full length of the log. At right-hand mills turning down, the cutting sequence usually is face 1, 2, 3, and 4. At right-hand mills turning up, the sequence is usually face 1, 3, 4, and 2.

Logs with spiral cracks (B, fig. 7-26) are placed so that one end of the crack is as for logs with straight cracks and the damaged zone is downward and back toward the knees. At mills turning down, the first face is usually sawed until the crack appears on a board edge, after which the other faces are successively worked; but where spiral cracks extend for 1/3 or more of the circumference, the un-

affected faces are sawed deeply before short pieces are cut from affected faces. At mills turning down, face 1 is worked lightly, face 2 deeply, and the cant finished on face 3. At mills turning up, face 1 is worked lightly, face 3 is slabbed, face 2 is worked deeply, face 1 is worked nearly to the pith, and then face 3 is finished.

Shake, rot, or spider heart (several splits radiating from the pith) that is restricted to the center does not influence the manner of dividing the log to faces or sawing sequence. The undesirable core is boxed and discarded. Logs with shake or rot in the outer zone are placed on the carriage in such a way that a cutting face is parallel to the straight line connecting the ends of the arc of shake or the long axis of the rot area, and the face affected is sawed last.

Logs with wormholes should be placed on the carriage so that faces visibly free from holes are sawed before the log is turned to the affected areas.

Indicators of degrading defects listed up to this point usually are detected from the ends of the log. Indicators detected from surface inspection, such as bud clusters, bird pecks, bulges, bumps, burls, butt scars, cankers, conks, holes, knots, overgrowth, and wounds, can be treated as a group so far as they influence the manner of dividing the logs into faces and the sawing sequence. Logs will include the full range between those with few indicators affecting a localized area and those with many indicators that are dispersed over the entire surface. Surfaces free of indicators are determined as the basis for initially placing the log, and it is then successively turned so as to cut the high-grade material from these faces before deep cuts are made into the defective ones. Thus, for a log with three high-grade faces, the defective one should be slabbed and turned down 90° or up 180°, depending on mill practice, the defective face being sawed last.

A log having a single high-grade face is placed with this face against the knees. At mills turning down, a 90° turn is used for successive faces. At mills turning up, the turning sequence after the first face sawed is 180°, 90° and 180°.

Where a clear face adjoins one having one or more defects that seem likely to be removed in edging, the log is placed so that these defects will be near the edge of the defective face. Cankers, conks, holes, and large dead knots, however, are indicative of extensive defects not likely to be removed by edging, and the sawyer should center them on the poor face (C, fig. 7-26).

Logs with sweep should be placed on the carriage with the sweep facing out, and the four faces should be successively worked in the sequence dictated by turning equipment. Better-grade recovery usually results when the widest boards are cut from the faces that are at the top and bottom with reference to the first face sawed.

It is important that the location of the faces be in accordance with the factors outlined. The high-grade faces are usually sawed parallel to the bark and the low-grade ones in the most convenient way to speed up the work. If a high-grade face is opposite a low-grade one, the good one should be sawed parallel to the bark. This can be done either by placing the poor one against the knees and setting out the small end of the log, or simply by placing the good face against the knees and slabbing the poor face first.

If the high-grade faces are opposite each other and the log is characteristically free of defects nearly to the pith (as with red oak, ash, and yellow poplar), one good face is placed against the knees and the other is partially sawed without regard to parallelism. In this manner each good face is taper-sawed and log length boards of high-grade will be obtained. If the log is characterized by interior defects that extend beyond the pith zone (as with sugar maple and birch), the small end is set out enough to permit cutting a slab of uniform width the full length of the log. When the opposite good face is turned to another, the cut is "straightened" by retracting the taper levels, setting the small end back against the knees, and sawing the face to produce a cant with opposite faces parallel. The purpose of this is to take out the taper from the low-grade material in the core instead of from high-grade material in the outer zone.

When slabbing parallel to the bark, the face of the slab should be the minimum width required by the prospective board grade of 6-1/2 inches for grades above No. 1 common and 3-1/2 inches for No. 1 common or lower. With any face, a 4/4 cut is usually taken next to the slab in order to minimize edging waste, but if the face is opposite a previously sawed one, the sawyer slabs so that the final piece will conform to the size requirements, thicknesses, or widths of the intended item. Faces indicative of high-grade material are sawed deeply, those indicative of low grade lightly.

The usual practice is to continue sawing a face until the grade drops to that promised by the adjoining faces. This progressive turning continues either until the central portion is sized to meet construction item specifications or until the grade improvement fails to pay. For small mills that specialize in cutting factory lumber, such turning is justified as long as lumber better than No. 3 common can be cut.

PROCEDURE FOR EDGING

Material for random size use normally is edged to get the maximum width possible in inches and fractions; for construction items, it is edged to conform to definite width specifications.

The minimum width for dry random size lumber is 5 inches for firsts and seconds and 3 inches for common. Normally, a shrinkage allowance of 1/16 inch per inch of width is made, so that green firsts and seconds should be at least 6-3/8 inches and green common at least 3-3/16 inches in width. Boards are usually edged with the narrower (bark) face up.

Boards below firsts and seconds are edged so that the surface area of the wane or rot left on the board is approximately equal to the area of sawed, sound face of the edging (see D, E, and F, fig. 7-26). For first and seconds, wane and rot cannot exceed 1/12 the surface measure nor aggregate more than 1/12 the length of the piece. Shakes and splits in firsts and seconds cannot aggregate in inches more than twice the surface measure of the piece in feet nor diverge from the parallel more than 1 inch per foot of length, unless they aggregate 1 foot or less in length. They should be removed by ripping or trimming if they violate this requirement in firsts and seconds or extend more than 1/3 the length of the piece in common grade.

All pieces exceeding 16 inches in width should be ripped if the grade of the resulting two boards does not fall below that of the wide piece.

Boards are ripped to raise the grade when 1/2 or more of the original surface measure is raised at least one grade.

Material for specific construction jobs is edged to conform to definite width requirements. Items may be made from a limited number of species and sized to a restricted series of widths, thicknesses, and lengths as for car stock (flooring for box cars) and construction boards. The sawyer, edger operator, and trimmer must know the size, species, and allowable-defect provisions of grading rules for such items. The 1/16-inch allowance per inch of width should be made to take care of shrinkage from the green to the dry condition. Material in thickness exceeding 3 inches is normally edged on the headsaw. A high percentage of all construction items is produced by the headsaw from squared cants and requires no edging. The small amount requiring it is edged according to the size and quality specifications for the particular product. These products are usually so diverse that general edging instructions cannot be given.

PROCEDURE FOR TRIMMING

Each piece should be trimmed 2 inches over the nominal foot, and boards below firsts and seconds should be trimmed so that the surface area of the wane or rot left on the board is approximately equal to the area of the sawed sound face of the trim (D, fig. 7-26). For firsts and seconds, wane or rot in excess of 1/4 the affected area within 1 foot of the end must be trimmed, and at least 1/2 the area of this last foot must have clear face. The rule for edging boards with splits in firsts and seconds also applies to trimming them; they are trimmed so that splits aggregate no more in length in inches than twice the surface measure in feet, nor diverge more than 1 inch to the foot in length, except when 1 foot or shorter.

For specific construction jobs, each item is trimmed to conform with specific length requirements and with wane, shake, or crack provisions for the item as listed in the applicable grading rules.

SAWING OVERSIZED LOGS

There is no efficient method of cutting, by the sawing-around technique, logs that are too large for the headsaw.

Logs with diameters nearly twice the height of the portion of the saw above the bolsters can be reduced in the manner outlined below.

Set the log to the saw so that the saw line will be a distance from the face of the knee equal to the height of the saw above the bolsters, and cut a line (A, fig. 7-27).

Dogs must be fixed to hold the log firmly; feed must be slow. The log is turned up exactly 90° and the stock items sawed. Sawing is discontinued before reaching the log pith or center (B, fig. 7-27). This series of cuts should extend

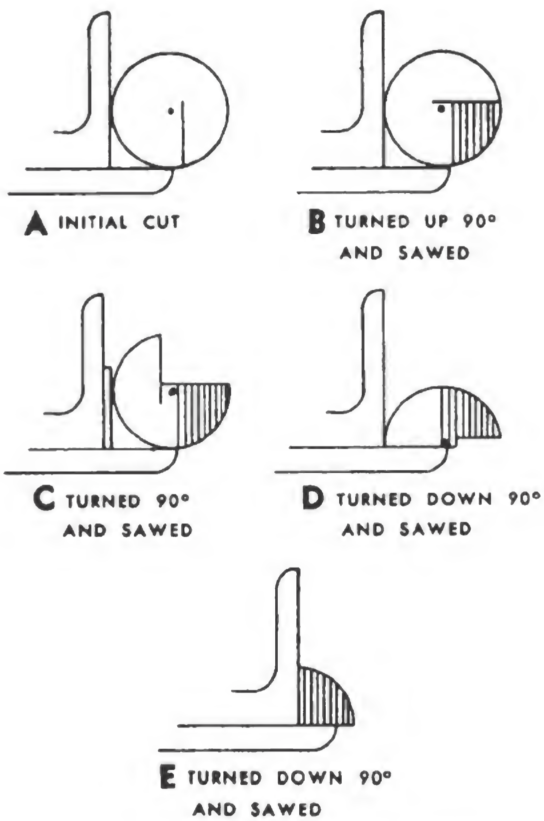


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Figure 7-27.—Sawing oversized logs.

exactly to the first saw line. The log is again turned up 90° and the small end is set out so that the ensuing saw lines will follow planes parallel to the first saw line taken. The stock items are sawed, sawing being discontinued before reaching the center (C, fig. 7-27). The log is turned down 90° and stock items sawed until beyond the center (D, fig. 7-27); then the log is turned down 90° and finished (E, fig. 7-27).

CAUTION: This procedure is extremely difficult and should not be attempted by any but thoroughly experienced sawyers. Otherwise, considerable damage can be done to the saw and sawmill equipment.

Powered drag saws and chain saws are sometimes used to reduce oversized logs to segments that can be cut on the head rig.

SIZE STANDARDS

Lumber, timbers, and ties must meet the precise size standards given in military specifications. With timbers and ties, the sizing problem concerns allowance for sawing inaccuracies; with lumber and light framing, it concerns allowances for sawing inaccuracies and, in addition, a green-to-dry shrinkage allowance.

The causes of inaccurately cut lumber are:

1. Faulty condition of the saw, which may be due to teeth that are out of line with the perimeter, holders or teeth out of line with the saw plane, excessive or uneven swage, teeth that are dull on one side, or incorrect tension.
2. Worn bearings in the mandrel, the carriage wheels, or the setwork.
3. Poor installation of the carriage and saw.
4. Lodging of chips between the log and headblock or on the tracks.
5. Careless setting or miscalculation.
6. Inaccurate manipulation of the dogs, or use of types of dogs mechanically unfit to hold the log firmly.
7. Frozen timber or unequal stresses in the wood.

COMMON CAUSES OF FAULTY SIZING

Faulty sizing may be traced to various causes. A few of the common causes are discussed below.

DOG BOARD THICKER OR THINNER AT TOP THAN AT BOTTOM EDGE. Faulty alignment of the saw and headblocks will cause unequal thickness of the dog board. The knee face should be at right angles to the top of the bolster, and the saw plane should be parallel to the knee face. The specific cause of this type of inaccurate sizing can be in the track, carriage, or saw mandrel.

The cause of the misalignment can be checked by stopping the carriage so that the headblock is opposite the saw, placing one leg of a carpenter's square along the face of the knee and then flat against the saw. If either the saw or the knee face fails to show a right-angle relationship to the bolster top, the adjustment is faulty. Each headblock should be checked. The simplest way to correct this difficulty usually consists of leveling the track, but where faulty alignment is due to worn headblocks, they should be replaced. Bolsters should be firmly anchored to the carriage bed.

DOG BOARD THICKER AT ONE END THAN OTHER, OR VARIES IN THICKNESS BETWEEN ENDS. Variations in thickness along the length of the dog board may be due to a twist or dip

in the track, to side-play between carriage frame and wheels, to misalignment of knees, or to end play in the saw mandrel. Track alignment can be checked by stretching a fine brass wire just clear of the top of the guide rail from the deck to a distance of a carriage length beyond the saw. Sideplay can be detected by giving the carriage frame a vigorous sideward shove.

The check of knee alignment consists of setting the faces of the knee so that they are about 2 inches from the front of the bolsters. To do this, the carriage is stopped so that the front knee is opposite the saw. The exact distance from the saw blade to knee face is then measured, the place on the saw where measurement is taken being marked; the rack of the knee should be tight against the pinion of the set shaft. Then, the carriage is moved to bring the next headblock opposite the mark on the saw and measurement is taken as for the first block. This procedure is repeated for all headblocks. All readings should be identical. Differences in readings may be due to a sprung set shaft, to a worn rack and pinion, or to loose or worn keys on the pinion. Most mills provide for some adjustments, either by resetting the rack or by recoupling the segments of the set shaft, but worn parts call for replacements.

End play of the mandrel can be detected by trying to force it toward or away from the track, using a lever on the driver pulley.

CONSISTENT FAILURE TO CUT BOARDS OF SIMILAR THICKNESS. Inconsistent thickness may be due to causes already listed or to dogs, setwork, or saw. One source of inaccurate sizing is inherent in the setwork mechanism of many small mills, the pinion-rack connection being so loose that the knee can be moved backward or forward as much as 1/2 inch without recourse to the set lever. Such looseness also results from worn gears. With fast feeds this looseness can cause a light cant to pull toward the saw. Faulty sizing also results from play in the setwork gears or in the pawl contacts. Either is usually traceable to worn keys, cogs, or pawls. Faulty sizing may also be due to miscalculation by the setter or to lack of a fixed backstop, which makes it difficult to set the exact interval desired in the setwork.

Faulty sizing from slack dogging has shown up in fast feeds or when sawing cants that have unbalanced stresses ("springy" timber). Some types of dogs are better designed to hold the cant more firmly than others. The boss dog normally grips firmly and draws the cant tight to the face of the knee. Dull tooth points, knots, or loss of the correct hook when the point is sharpened may result in faulty sizing.

The saw can be the source of faulty sizing if the mandrel has end of play, if the lead is not correct, or if the fitting of plate or teeth is incorrect. If any of these conditions are present, the saw has a tendency to deviate when overloaded, as when using excessively fast feeds, cutting hard or frozen woods, or making deep cuts. A dull saw is more erratic than a sharp one.

TALLYING AND GRADING

A daily TALLY of green lumber cut at the mill is kept by small mills. As a rule, small mills depend upon recording the amounts of product shipped out of the yard and the amounts in the yard as shown by periodic inventories. Large mills usually record the daily production at the green chain (conveyor which carries finished lumber to the loading dock); or, if the product is shipped green, by truckloads.

Usually all species are lumped together, but a series of tally sheets may be used where separate tally by GRADE AND SPECIES is possible. At some mills where edging is done on the headsaw, the sawyer records items on a tabulation sheet. Headings are written in for each size (length, thickness, and width) normally sawed and a dot placed for each item sawed. Footage is computed from these records.

CARE AND MAINTENANCE OF SAWS

Various factors concerning the care and maintenance of saws are described in the following paragraphs. While headsaws are considered primarily, the statements are generally applicable to the other types of saws as well.

TENSIONING SAW

Forces acting to stretch the rim of a circular saw are centrifugal force, or the outward pull of the revolving plate; resistance to cutting; and heating of the saw when grinding out its gullet ("gumming" it). These are enough to expand the rim so that the saw will fail to hold to a true line unless it is properly treated. By stretching the midradial area uniformly, that is, tensioning it, the rim is steadied, so that the saw holds a true line. The midradial area is that area of the entire saw which lies one half the distance between the saw's center and its perimeter.

The amount of tension given this midradial zone is governed by certain considerations. A large saw requires more tension than a small one; a thin saw more than a thick one; a high speed saw more than a low speed one; and a heavily loaded saw more than one under light load. The measure of tension is the extent to which the midradial zone sags below a straightedge held on the radius when the saw is supported as shown in figure 7-28. This sag may be as little as 1/75 inch on small, slow speed headsaws, or as much as 1/12 inch on large, high speed ones, since the amount of sag determines the extent to which the rim of the saw can expand without deviating, as discussed above.

Tensioning by Hammering

A competent man can acquire the skills of leveling and tensioning saws. Where and how much to hammer must be a matter of judgment for each tensioning. This can be acquired by experience.

The tools suggested are a trial mandrel, a hammer bench with running board or back rest, a 150-pound anvil with crowned face, a 4- by 5-pound square-faced hammer, a 4- by 5-pound round-faced hammer, straightedges 6 and 60 inches in length, and a tension gage. A trial mandrel is shown in figure 7-29; a number

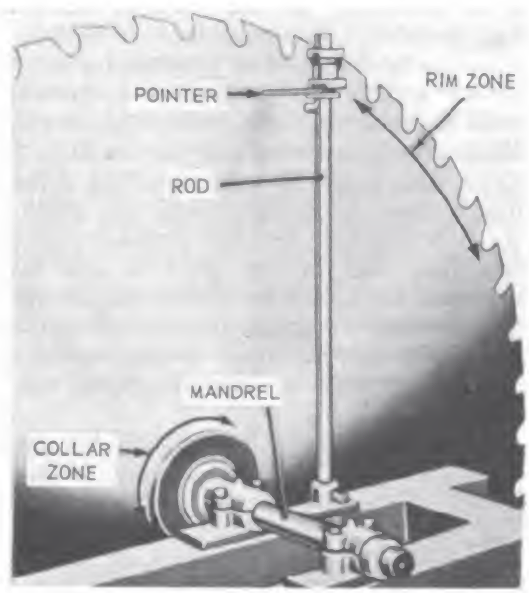

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Figure 7-29.—Trial mandrel.

of other types of equipment used for tensioning are illustrated in figure 7-30. The 6-inch straightedge is used to determine the size and shape of small, localized high areas. The 60-inch straightedge is used to determine whether or not the saw is tensioned evenly over its entire

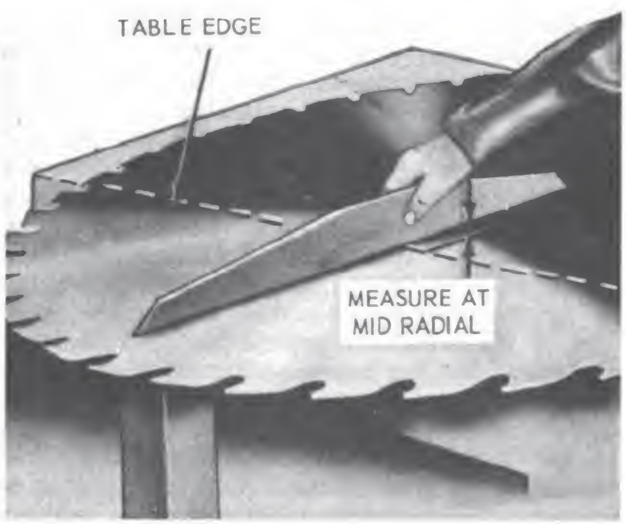

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Figure 7-28.—Method of measuring tension in a circular saw.

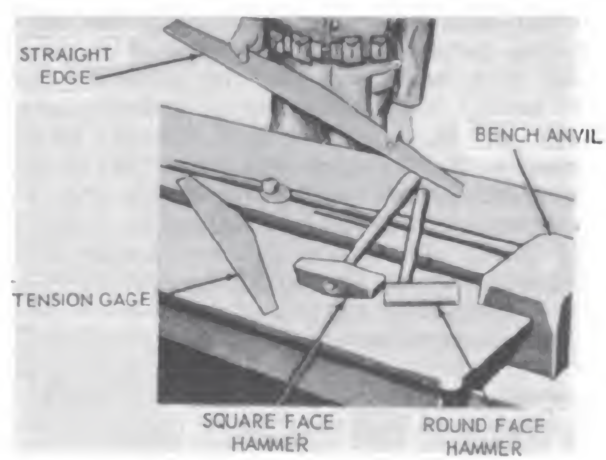

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Figure 7-30.—Equipment for tensioning saw.

surface. The tension gage is a straightedge altered to conform to the arc of curvature when the properly tensioned saw is tested for "drop." A headsaw gage can be made by dressing the edge of a thin strip of steel to fit exactly the arc of curvature of the correctly tensioned saw. When the saw is given the tension test, one end of the gage is placed about 4 inches from the bottom of a gullet and the other end about 4 inches from the eye (center hole) of the saw. One end of the gage is marked so that the same end can be placed at the rim in all tests. Neither the gage nor the straightedge should be allowed to lean from the upright position. They should be pressed gently against the plate.

To put a saw in condition, check for twists, lumps, and other high spots. Level these imperfections. Then put in the correct tension. The gage will indicate where to hammer for correct tension. To get background on the degree of uniformity sought in a properly leveled saw, put a correctly leveled and tensioned one on the trial mandrel, fix the pointer (fig. 7-29) so that it barely clears the plate about 1 inch below the base of the gullet, and then slowly turn the saw, noting the degree of variation in the gap between the plate and the pointer. Check for uniformity at 2-inch intervals along a radius from the rim to the collar line.

The trial mandrel (fig. 7-29) must be flawlessly straight and held true in the bearings; saw collars must be perfectly fitted and planed. The rod to which the pointer is attached should be parallel to the planed faces of the collars.

To learn how hard to strike a saw for tensioning purposes, spread a film of oil over an area of a discarded saw and place the saw on the anvil. Practice striking it until the face mark left by a round-faced hammer is maintained at a 7/16-inch diameter. This diameter should never be greatly exceeded; one of 5/8 inch indicates excessively heavy blows. In leveling, blows are ordinarily less severe than in tensioning, since leveling is preparatory to tensioning and must not impart any tension but only correct uneven surfaces.

Procedure For Finding High Areas

Put the saw requiring fitting on the trial mandrel. Turn the saw slowly and, where the gap between pointer and plate diminishes beyond the standards set up previously, draw a short chalk line on the plate. Repeat for each of the concentric circles 2 inches apart. The result should be a series of marks indicating areas of high spots. In some cases, high spots are indicated by particularly bright metal; in extreme instances, the metal may be blued by heat generated in sawing.

These marked areas result from lumps and twists in the saw and must be hammered out. Before the saw is taken from the trial mandrel, the extent and direction of these high spots should be confirmed by placing a 6-inch straightedge against the plate in such a way that it is centered on a marked high area. By sliding the straightedge in different directions over it, the size and shape of the high area can be correctly delineated and marked.

Put a double sheet of wrapping paper, or a pad of thin belting, over the anvil. Place the eye of the saw in the socket with the marked side of the saw up, and center one of the spots on the anvil. In all hammering, whether for leveling or tensioning, move the saw as needed to bring the anvil squarely under the blow. Circular high spots can be taken down with either the round- or the square-faced hammer. Strike blows beginning at the center of the area and following a line to the margin. Space the blows about an inch apart, and taper off on the force of the blows in progressing to the margin. Place succeeding series of blows on lines from center to margin, as in the first case. Exercise care that the blows are no harder than needed; too heavy pounding drives the high spot beyond the level condition and complicates later tensioning. Do not expect to level the lump completely the first time over the saw. In using the square-faced hammer, a second blow is struck directly over and at right angles to the first.

For linear areas (twists), center the area over the anvil and hammer it so that the long axis of the square-faced hammer is along, rather than across the twist. Blows are spaced about an inch apart. The first line hammered should conform to the axis of the twist. Follow up by hammering a series of lines on each side if the width of the raised area indicates the need. Do not hammer the area inside the collar line or the 4-inch zone next to the base of the gullets at this stage, but level completely the mid-zone area.

Having gone over the areas indicated to be in need of hammering, put the saw on the trial mandrel with the other face to the pointer, and mark the high spots as before. Those requiring leveling are hammered out. Chalk marks are cleaned from the saw, and the process of

remarking and hammering is repeated until the saw is properly leveled.

Determining Tension Attained

The saw is now ready to be checked for tension. With the saw on the trial mandrel, place the long straightedge firmly across the plate as close to the diameter as permitted by the collar. This diameter-wise application of the straightedge is repeated on 6 diameters equally spaced to divide the circumference into 12ths. The saw is evenly tensioned when the straightedge contacts it over its entire length at all checks. The initial checks will usually disclose high and low areas.

Low areas indicate relatively great tension, and they should be outlined and omitted when hammering. The rest of the plate may contact the straightedge throughout the diameter, or unleveled lumps or twists may show as localized high spots. Mark and level these twists. Eventually the straightedge will be completely in contact except at the low areas.

In hammering the low areas inscribe a series of concentric circles centered at the eye, the outer one about 4 inches from the base of the gullets and the others at 3-inch intervals until within about 2 inches of the collar line. For saws run at less than 700 revolutions per minute, draw radii to alternate tooth points; for saws run at higher speed, draw radii to each tooth point. The intersections of the radii and the circles are the spots to hammer.

Place the saw on the anvil as for leveling, but without the paper cushion. With the round-faced hammer, strike a single blow at each intersection, starting near the collar line and progressing along the radius toward the rim. Then follow the next marked radius from the rim toward the center. Continue this until all intersections to be hammered have been treated.

Uniformity of Blows

Uniformity of blows is attained by detailing to the tensioner the single job of hammering the plate. A helper at the bench side pulls or slides the saw between blows, so as to bring consecutive marked intersections over the center of the anvil. The saw is moved at a uniform rate in order not to interrupt the steady, even tempo required for uniformity in hammering. The tensioner stands in the position best suited to the individual for accurate hammering over the center of the anvil.

Leveling Opposite Saw Face

The saw is next marked on the opposite face with the identical pattern of radii and circles, so that hammering is done directly over targets on the reverse side. A single blow of like magnitude is given at each marked intersection.

The saw is then placed on the bench and checked with the gage for uniform tension; areas in need of further hammering are marked.

This gage check is done by supporting one edge of the saw on the bench and raising the opposite edge so that the saw is supported only by the body and bench, and steadied by the left hand.

With the right hand, the gage is placed on a radius exactly halfway between the bench and hand supports, and the degree of conformity between the gage edge and the saw plate under it is determined.

If the gage touches at the midzone but not toward the ends, further tension is required for that area. If the end zones touch but light shows under the midzone, the midzone should not be hammered, since its tension is now correct.

Further Hammering

Blows are struck only in those areas showing need of additional tension. These blows usually are lighter. It is good practice to stagger the second series of blows from the original ones by placing circles and radii midway between those marked for the first treatment on the opposite face.

Final Check for Uniform Flatness

When the plate fits the gage on all radii, put the saw on the trial mandrel and again check the plate for uniformity of flatness by placing the long straightedge as close to a diameter as the mandrel nut allows. The plate should touch the straightedge throughout. If high or low spots show up, they are usually due to lumps. If in the rim or collar zone, these can be located by using a 6-inch straightedge while the saw rests flat on the anvil; otherwise, the 60-inch straightedge must be used with the saw on the trial mandrel. Hammering inside the collar line or at the rim zone must be done very carefully and only after thorough checks indicate that other zones are properly leveled and tensioned.

ALIGNMENT OF SAW
AND TEETH

A saw that is properly aligned and tensioned cuts faces without visible scorings. Scoring wastes both material and power. Tests indicate that approximately 10 percent more power is used in cutting scored faces than clean ones. Scoring results either because there is a flutter in the rim of the revolving saw or because holders or teeth are out of line. The rim flutter may be due to faulty tension or to faulty alignment of the mandrel or collars.

If the source of flutter is in the mandrel or collar, all saws will flutter. If the flutter persists even though the mandrel is held in place by its bearings, check the fixed-collar alignment.

The plane of the shoulder that bears on the saw plate should maintain, when the mandrel is turned, a uniform spacing with reference to a pointer that almost touches the collar (A, fig. 7-31). If it does not, the collar should be ground.

The alignment of holders and teeth can be roughly checked by inspection, or more precisely with a side gage (B, fig. 7-31).

Misalignment due to inaccurate placement of tooth or holder can usually be corrected by careful replacement after the contacts of tooth, holder, and saw are cleaned with an oiled rag. In more stubborn cases, they can sometimes be brought into line by tapping them lightly on the bulge side while holding a block against the opposite side.

Misalignment due to sprung parts can be determined by inserting a tooth and holder that is in line with its own setting. If it is out of line, the tooth can be brought in line by putting a saw set on the plate just back of the heel of the tooth and pulling the tooth in line.

A loose holder can be stretched by placing it on an anvil and striking a series of blows with the round-faced hammer at points indicated in A, figure 7-32, repeating this procedure on the opposite face.

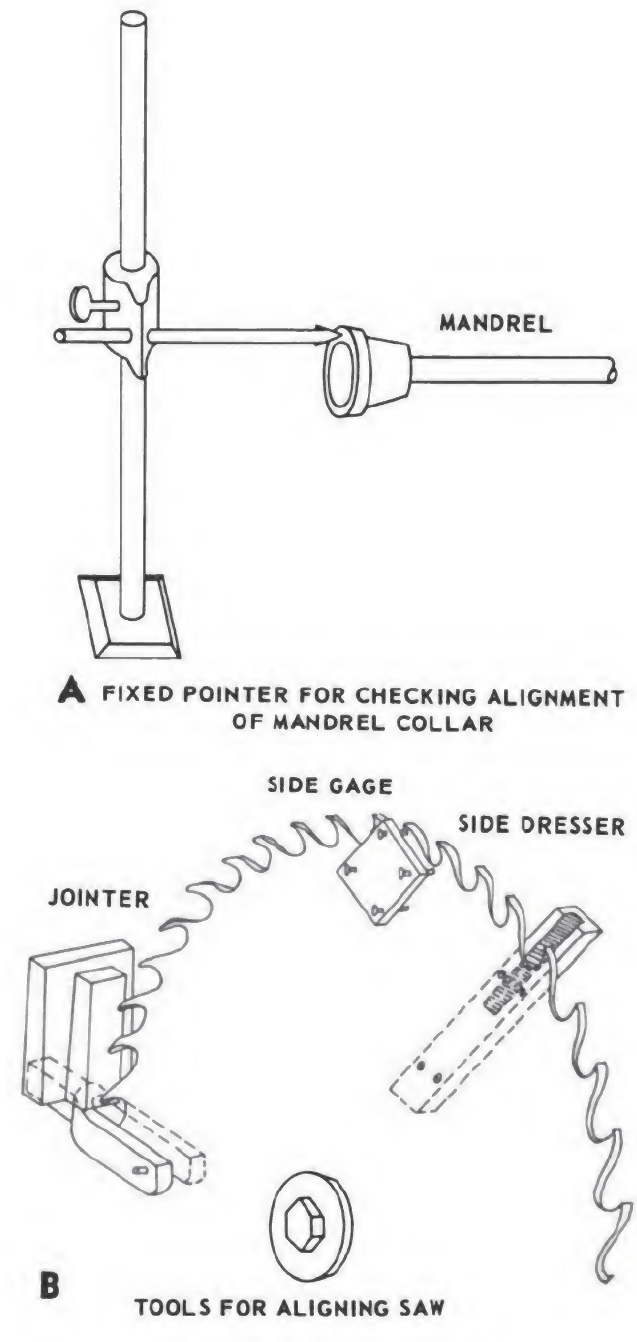
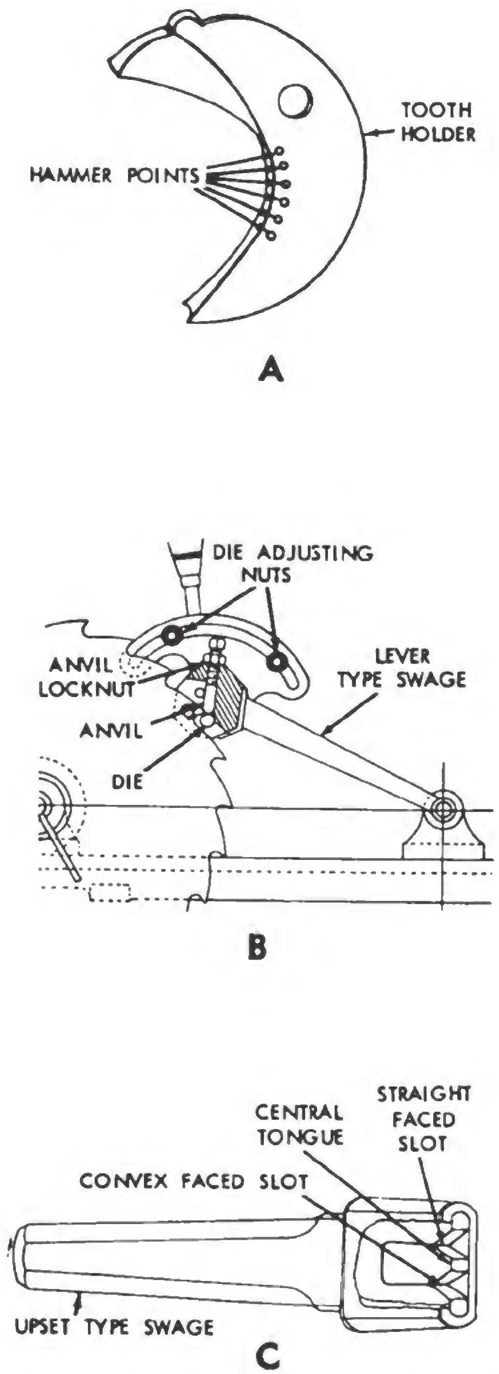


Figure 7-31.—Alignment of saw.

FILING CIRCULAR RIPSAWS

Filing, as an operation, includes sharpening, swaging, sidedressing, jointing, and gumming (grinding out the gullets). The method of filing circular ripsaws is determined by the hardness of the teeth. The teeth of standard solid-toothed saws can be shaped and swaged with standard saw-fitting equipment, and cutting edges can be maintained with a file or emery wheel. Likewise, standard inserted points differ only slightly in hardness from the plate and can be maintained by similar equipment. The high-speed steel inserted points are not subject to swaging nor can they be sharpened with a file, but require an



A. Small circles indicate where to hammer tooth holder to stretch it

B. Lever type swage

C. Upset type swage

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Figure 7-32.—Tooth holder and swages.

emery wheel. Still harder alloys are shaped for the cutting parts and welded or brazed to inserted and solid types of teeth. These require special sharpening wheels and cannot be swaged.

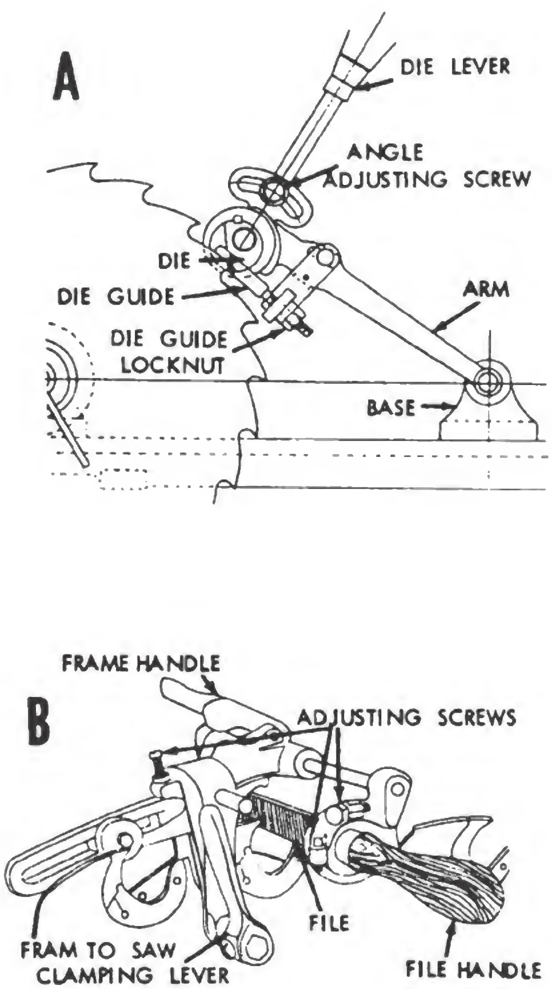
The teeth of solid-tooth saws can be fitted by swaging, sidedressing, jointing, gumming, and filing to restore their shape; inserted teeth are chiefly filed or ground. It is usually unnecessary to swage inserted points, since the design ensures adequate clearance (of tooth thickness to blade thickness) for the useful life of the tooth. If swaging of inserted points is attempted with the upset swage (C, fig. 7-32), the teeth should be held in a discarded plate or section in order to avoid damaging the milled juncture of the plate with the tooth and holder. If the lever type of swage is used, the anvil must be carefully adjusted to avoid gripping the tooth too far back, since the hard points crumble or crack under excessive spreading.

Solid teeth are swaged and usually filed two or three times, after which their shape is restored by swaging, sidedressing, jointing, and gumming. For swaging, either a lever type of swage or an upset type is used.

The lever type swage (B, fig. 7-32) draws the front of the tooth out and flattens it between an anvil and die. The anvil is adjusted to bear squarely on the top of the tooth, and the die contacts the underface back of the cutting edge. The die is slightly eccentric, so that when turned with the hand lever, it flattens the metal at the end of the tooth. This swage is usually fixed to a bench for shop service or, with a slightly different frame, can be used when the saw is on the mandrel.

The upset swage (C, fig. 7-32) battens the point. If the upset is used, the central tongue should be above the point and the point inserted in the slot having convex faces, with the back of the swage held on a line with the back of the tooth. A single blow is struck lightly with a 1-pound hammer. Then, reversing the swage so that the central tongue is still above the point, the tooth is inserted in the slot with straight faces and hammered as before.

After the tooth has been swaged, its sides may be given uniformity by sidedressing them with a file mounted on a block (B, fig. 7-31). Blunt-end screws that can be adjusted pass through this block to keep the file the required distance from the saw plate; or uniformity can be obtained by using a shaper (A, fig. 7-33) to pattern the sides of the swaged area by compressing the sides of the tooth between dies.



A. Tooth shaper
B. File in frame for sharpening teeth.

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Figure 7-33.—Tooth shaper and file frame.

Jointing, which usually follows swaging, is done only to bring all teeth to a true peripheral circle. Before inserted points are joined, holders and teeth must be tight and in the true plane of the saw. Jointing is done by bringing an emery stone or file against the cutting edge of the revolving saw. The stone, or file, is fixed to a block or base (B, fig. 7-31) and is supported by the saw-guide bracket. At first it should engage only the highest teeth; then it is advanced very slowly, until all teeth finally engage.

Gumming (the process of cutting out the gullets of a saw) is done with a power-driven emery wheel. Usually, provision is made for automatically grinding the desired tooth and gullet shapes progressively around the saw.

In using such an emery wheel, burning of the saw metal must be avoided; that is, the wheel must not be forced against the metal so hard that the metal shows a blue tint. This is avoided by adjusting the emery wheel to grind the gullet lightly at first and not directly under the cutting edge; each gullet should be ground in this way before proceeding. Then the emery wheel is readjusted to deepen the gullet, and each gullet is ground until the wheel grinds the cutting edge of the tooth and completely around the gullet. Cutting parts of teeth that have been distorted by filing, wear, and swaging should be touched up with a properly adjusted wheel only after the throat and bottom of the gullet have been ground.

Gumming with a round file is not usually practical on headsaws because of the labor involved and the difficulty of maintaining uniformity of tooth shape and spacing. Gumming is done only on solid-toothed saws and requires emery wheels of specific pattern for that purpose.

Inserted points are usually sharpened with a file or emery wheel without removing the saw from the mandrel. Three machines are available for sharpening the saw on the mandrel.

One machine consists of a frame supporting a standard file in position as in hand filing, uniform surface contact being assured by means of frame supports as the file is pushed across the underface of the tooth (B, fig. 7-33).

The second machine consists of a frame that supports a handcranked wheel faced with file segments, which can be adjusted to surface the face of the tooth (fig. 7-34).

The third machine consists of a frame supporting an adjustable emery wheel to surface the face of the teeth. Power is supplied through a flexible shaft, by either handcranked gears or a motor.

All three machines, when properly adjusted, permit facing the tooth squarely; the emery wheel can be set to grind a definite tooth spacing.

In filing by hand, individual skill instead of mechanical guides must be relied on to surface squarely across the underface on the plane, in order to give the desired hook uniformly to each tooth.

A round-edge, mill type file 8 to 10 inches long is recommended. The filer can work at

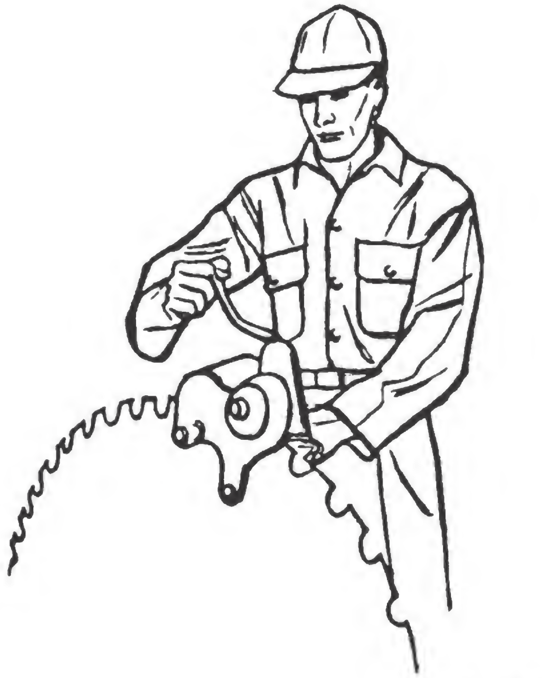

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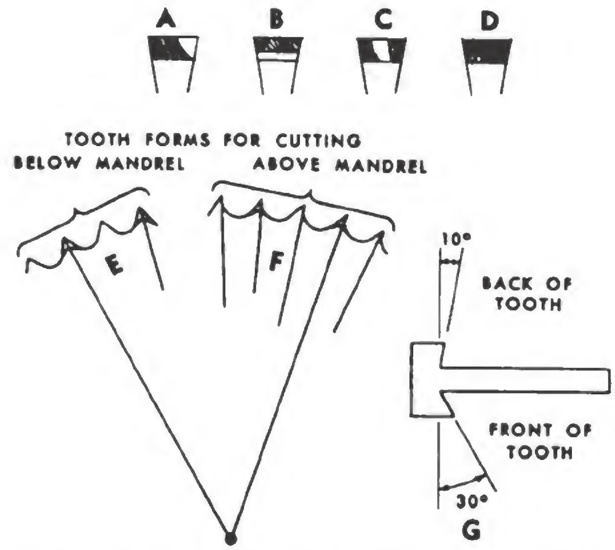
Figure 7-34.—Tooth sharpening machine.



A. Stroke Straight, but not in Plane of Saw Tooth
B. Stroke not Parallel with Plane of Tooth Face
C. Stroke made with a Rolling Motion
D. File Bears Equally on all Parts of Tooth Face
E. Form for Cutting Done Below Mandrel
F. Form for Cutting Done Above Mandrel
G. Gage for Checking Front and Back Bevel on Trimmer Saws

117.262
Figure 7-35.—Filing patterns and trimmer saw gage.

the top of the saw or somewhat back of the top. When filing at the top, he stands on the track side, facing the saw with his shoulders at about 45° to the saw plane.

The file is pushed full length straight from the shoulder without dropping the elbows. It is held firmly against the face of the tooth by gripping the handle with one hand and the point with the other.

In gaining experience, it is a good plan to first place the file against the face of a tooth so that the lower edge is free of the throat, noting the zone of the file face that can be used without touching the throat. Then, about three strokes are taken and results studied.

A stroke that was straight lengthwise of the file, but was not in the same plane as the tooth face, is indicated in A, figure 7-35. This results in a slanting cutting edge (high corner).

A stroke made when the plane across the file was not parallel with that of the tooth face is indicated in B, figure 7-35. This results in decreased hook.

A stroke in which a rolling motion accompanies the thrust of the file, aggravating the dullness of a beveled face, is indicated in C, figure 7-35.

Filing should be practiced until consistency is acquired in stroking the full face, as in D, figure 7-35.

In actual sharpening, about five strokes are taken per tooth, but the number is varied according to the requirements of the individual tooth.

Only enough metal is removed to restore sharp cutting edges.

After the face has been filed, the cutting edge is tapped with the softwood handle of the file to remove the bur.

CAUTION: The back of the tooth should only be filed to remove distortion due to use of upset swage, never to remove the bur from filing. In filing the distorted tooth, extreme care must be taken to follow the back angle of the tooth. Otherwise, the saw may "dodge" or "run" in the cut.

When filing a saw on the sawmill mandrel, the filer usually sits back of the saw and facing the deck, the saw being between the knees. The

work is done at about shirt-pocket height. The stroke is parallel with the shoulders and more difficult to hold true than the straight thrust used in filing at the top of the saw.

CIRCULAR CROSSCUT SAWS

Trimmer, straight-line cutoff, and slasher saws function by cutting across the grain. Teeth are spring-set except that, in hollow-ground saws occasionally installed for smooth trimming, no set is used. To maintain teeth of uniform length, spacing (point-to-point distance), and shape, the saw should be jointed, the teeth spring-set and sharpened, the gullets gummed.

Tooth forms used when cutting is done below or above the mandrel are illustrated in E and F, figure 7-35.

Tooth spacing is 1-1/4 to 1-3/4 inches.

Tooth form E, figure 7-35, is developed by dividing the rim into intervals equal to the desired tooth spacing, and using each interval as the apex of a triangle having all sides equal.

The base of the gullet is rounded out so that the tooth depth is two-thirds the point-to-point distance, and a bevel is given as shown in G, figure 7-35.

Crosscut saws are often sharpened, set, and gummed with a power-driven automatic sharpener to insure that the correct shape and spacing of teeth are maintained. In filing, the guiding considerations are to keep the teeth of uniform length, shape, and spacing. The base of the gullet must be rounded and the face and back of the tooth beveled.

Several varieties of setting equipment are on the market that combine either a hammer-and-anvil or a vise-and-lever action. For straight-line cutoff and trimmer saws, 0.02- or 0.025-inch sets are suggested, and for slab saws a set with 0.03 inch on each side. The set should be started not more than 0.2 inch below the point. Uniformity in this point of departure and in the amount of set is usually provided for by the mechanism employed.

To sharpen the saw, the bevel is filed first, preferably with a round-edge file. Equal amounts should be taken from the front and back in order to maintain the correct shape and height, as well as uniform spacing, of the teeth.

The knife edge extends down from the point 1/4 to 1/3 inch. For slab and straight-line cutoff saws, a bevel of 15° on the front and 10° on the back of the tooth is suggested; for trimmer saws it should be 25° to 30° on the front and 10° to 15° on the back.

Guesswork can be eliminated by using a gage cut from heavy tin plate, as shown in G, figure 7-35. Between the knife edge and the base of the gullet, the tooth is filed straight across sufficiently to maintain the correct outline. The base of the gullet is deepened and rounded with a round file.

Guidance for uniformity of gullet depth is gained by drawing a circle centered on the eye, with a radius not quite to the base of the gullets.

SAFETY

Safety is a matter of chief concern to everyone working at or around sawmills. Accidents may mean serious injury or death to workers, as well as extensive damage to equipment. As a BU 1 or C, see that your men know the safety precautions to follow, and try to develop a safety-conscious attitude on the part of every member of your crew. Some of the primary precautions applicable to sawmills and saws are given below.

SAWMILL SAFETY

When selecting a sawmill site, avoid soft or spongy ground. The trackway, husk, and foundation timbers must remain absolutely level after the sawmill is erected. If any part of the sawmill settles lower than the other parts, it may cause serious trouble.

When the headsaw is operating, always secure the sawyer's lever in the neutral position when it is necessary for the sawyer to leave his position. Swing the neutral stop rest to the left and against the sawyer's lever. This prevents the lever from being accidentally moved to either of the engaged positions.

Before running the carriage past the headsaw under engine power, always make sure there is proper clearance between the headsaw and the three headblock bases. Push the carriage past the saw by hand to check clearance. Be sure the head is stopped when checking the clearance between the headblock bases and headsaw.

When removing or installing the headsaw, use heavy gloves if available. If gloves are not available, use pieces of heavy canvas or other cloth to protect the hands from injury by saw teeth.

When operating the cutoff saw, make sure that footing is secure. If footing is slippery,

place heavy boards on the ground and across the dust hole.

Do not apply nonslip belt dressing to the feed belt or backing belt. These belts must slide freely on the pulleys when the sawmill is idling.

Do not attempt to stop a board already started into the front feeder rollers or to change its course. This may result in injury to personnel or damage to the equipment.

Do not use the pawl release lever to stop the receding action of the knees. This harmful practice will throw unnecessary strains on the setwork parts and cause rapid wear on pawl holders and the ratchet wheel. Always use the brake to stop the knees at the desired position.

Every time the adjusting screws for the seven V-type drive belts are disturbed, be sure to check the mandrel for alignment.

The sawyer, as well as the entire crew, must constantly be on the alert to avoid accidents which could cause injury to himself or to others. Every crew member should avoid forming careless operating habits which cause unnecessary wear and tear on the working parts of the sawmill. To prevent accidents, the sawmill crew should follow these safety rules and suggestions:

Keep trash, rags, and tools from carriage platform.

Keep knots, slabs, or tools from husk cover box.

Do not allow slabs to accumulate around edger.

Keep slabs, boards, and knots from trackway.

Make sure the carriage foot guards are fastened tightly at all times.

Sawyer must never remove hand from sawyer's lever when saw is running unless the neutral stop is holding the lever in neutral position.

Always keep the husk cover box on husk when cutting lumber.

Avoid working too close to the edger drive belt and feed belt.

Avoid wearing loose, ill-fitting clothing when working near saws, belts, or pulleys.

Always wear gloves, if possible, when handling saws, tools, equipment, and timber.

Avoid piling too many logs on log skid.

Avoid careless piling of crooked logs which might roll into personnel or equipment.

Always use cant hooks and peavies to move and handle logs. Do not use hands, feet, or timber sticks for this purpose.

Use wedges or blocks to prevent logs from rolling into equipment.

Keep walkways clear of bark, slabs, knots and tools.

When sawing logs with loose bark or with loose splinters, place the safety screen between headsaw and sawyer.

Avoid careless operating habits which might result in tripping and falling into saw.

Do not operate the cutoff rig unless the guard box is installed.

Do not handle logs with broken, damaged, or dull cant hooks. Keep hook points sharp.

Do not burn slabs or dust close to the sawmill.

Do not install or adjust the saw guide pins while headsaw is running.

Do not crawl under or over the power unit universal joint when the saw is in operation. Build a box guard and steps over and around the universal joint, and a skeleton guard at the side of the edger drive belt.

When sawing at night, make sure the sawmill is sufficiently well lighted to permit safe operation.

When removing small splinters or bark from the husk cover box near the saw, use a long stick, not the hands.

Do not walk on the husk cover box while the saw is running.

After installing the sawmill, run the carriage past the husk by hand before operating it under power.

Do not operate the saw when the belts are only partly connected, or when the connecting pin is broken or damaged.

Make sure large crooked logs are securely dogged before starting the cut. This type of log is liable to break away when the saw is part way through it unless the log is held firmly in place. Such a breakaway may injure personnel as well as damage equipment.

Always watch for imbedded metal objects in log. Spikes, wires, lag screws, or shell fragments should be chopped out. Better yet, do not saw this part of the log.

Make sure the saw guide is in place before starting a cut. All drive belts and pulleys shall be adequately guarded.

If a knot of a slab becomes caught in the edger rollers, do not attempt to dislodge it with the edger running. Stop the sawmill.

Do not try to run badly split or shattered boards through the edger.

Do not remove heavy knots or slab ends wedged between headsaw and husk cover box by standing on top of cover box. Stay away from saw, and either use a cant hook or stop the saw.

Do not kick off the last board (backing board) when carriage has started back and is too near

the saw. Make sure the backing board does not fall into the saw.

The sawyer is responsible for the safety of the entire crew, especially those on the carriage. Hence, the sawyer must avoid careless operating habits such as jerky, uneven application of the sawyer's lever. This practice may throw crew members off balance and into the saw.

Before starting any repairs on the sawmill, stop the engines. Remove the battery connections to prevent accidental or unauthorized starting of the engines.

The frequency of fires in mills is very high, and the control of fire hazards must be a continuous effort.

SAW SAFETY

Never saw with a dull saw.

Never saw with a hot saw.

Do not allow chips to rub saw.

Keep saw clean of pitch. Pitch sticks only to a hot saw.

Always carry extra teeth for the saw and be sure to place them in oil before putting them in the saw.

When handling saws wear heavy leather gloves. Keep all parts of body protected when filing or handling saw blades. Wear protective clothing, including safety shoes, if available.

Use two men to handle and carry large-diameter saws.

Use goggles, or face shield to protect eyes from flying chips or particles, and when grinding or gumming with power-driven emery wheel.

LUMBERYARD OPERATION

After the lumber comes from the sawmill it goes to the lumberyard for drying and storage. As a Builder 1 or C, you may be placed in charge of operations at the lumberyard. To assist you in carrying out your duties in that capacity, we will discuss factors concerning the layout of the lumberyard. We will also explain various methods used in piling lumber.

LUMBERYARD LAYOUT

Green lumber, unless treated with chemical fungicides and insecticides, cannot be kept long without serious deterioration, principally in the sapwood. The speed and extent of deterioration depend largely on temperature, because fungi and insects are active during warm weather, less active during cool weather, and dormant in extreme cold. One way to avoid fungus and insect attack is to dry the lumber quickly, particularly the surfaces, to lower the moisture content.

The product of small sawmills is kiln dried; seasoning is done, if at all, in an air-drying yard. Figure 7-36 shows a sample lumber yard layout. The yard should be easily accessible from the mill. It should be on ground which is suitable for hauling and for pile foundations and which is open to air currents for lumber drying. Good air circulation and soil drainage and a level or slightly rolling surface are essential to meet these needs. Uneven or steeply sloping surfaces require excessive cribbing for pile foundations and grading for roads.

The ground should be kept free from debris and vegetation. Debris harbors fungi and insects and interferes with air movement. Vegetation restricts air movement over the ground surface and from beneath the lumber piles. When the vegetation becomes dry it creates a fire hazard. Vegetation can be kept in check by cutting, or can be killed with chemical weed killers.

A road or an 8-foot fire lane is constructed in a clear area, or a 30-foot lane in a timbered area around the margin of the yard is kept cleared of vegetation as a check against encroaching fires. Where organized fire protection is not available, water barrels and buckets should be placed according to a planned pattern. For example, they may be placed at the beginning and end of every fourth row, with enough intermediate barrels and buckets to keep the maximum travel distance to any one barrel at 75 feet. Adding 3-2/5 pounds of calcium chloride per gallon will prevent freezing of water at temperatures down to -20°F.

In general, yard layout should provide for wide alleys and ample space between piles to ensure good air circulation and adequate room for handling and hauling lumber. The layout should provide a clear space of 30 feet from temporary milling operations and 50 feet from semi-permanent installations. Main alleys should be 16 feet wide for motor truck or dolly hauling and hand stacking, or 30 feet wide for forklife truck hauling and piling, since forklift trucks move lumber with its greatest dimension at right angles to the direction of travel. The spacing between main alleys for hand-stacked piles is twice the length of a pile plus a rear alley of 6 feet or so, making a total of about 38 feet. With unit-package piles, stacked by forklift truck, the space between main alleys is optional, depending on the number and width of the piles in the rows

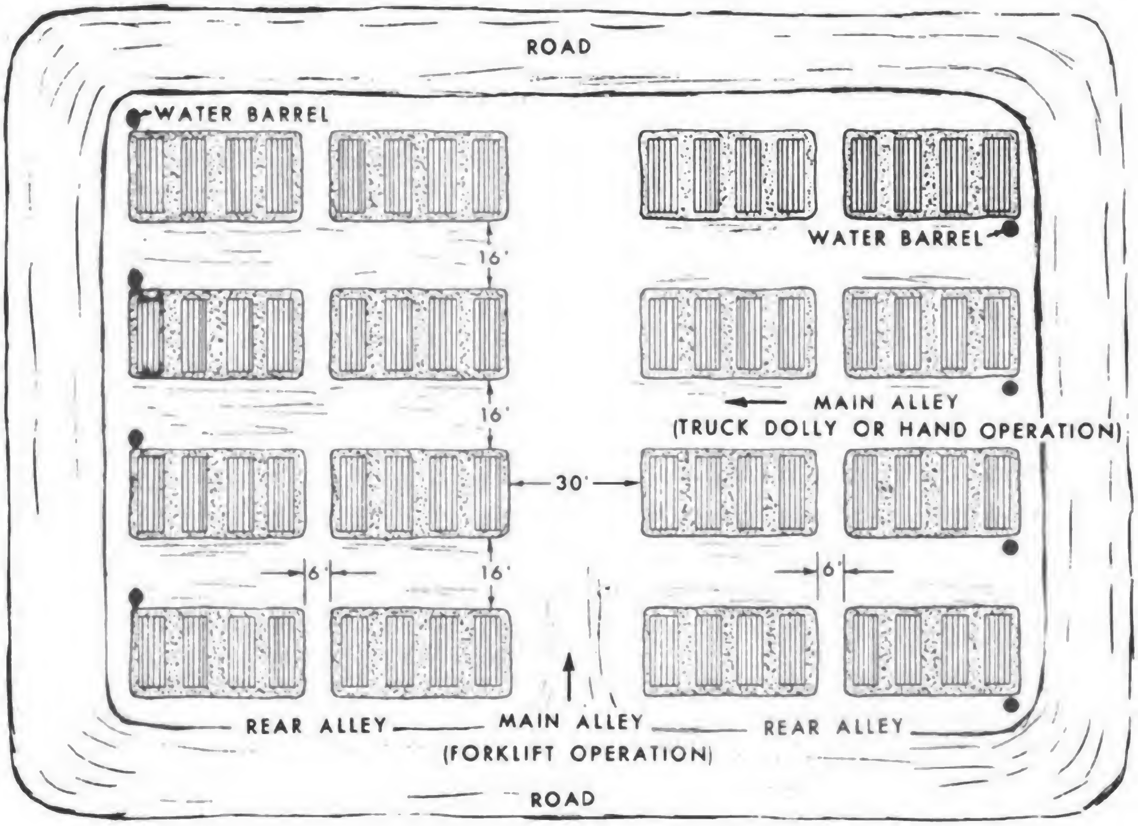


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Figure 7-36.—Sample lumberyard layout.

and the space between them. Cross alleys should be 16 feet wide for motor truck or dolly hauling, or 30 feet wide for forklift truck hauling, and spaced about 100 feet apart to give ready access to main alleys.

For hand stacking, it is suggested that the piles be 6 feet wide and about 10 feet high, with a space of about 2-1/2 feet between the piles. Unit packages for yard drying are generally about 4 feet wide, and are stacked three to five units high. A space of about 2 feet should be left between the piles of unit packages in a row, and 3 to 4 feet between rows.

LUMBER PROPS

The use of lumber props (fig. 7-37) in loading trucks is a quick and efficient aid. The props work on the same principle as the log preloaders (fig. 6-34). The yard supervisor should always emphasize the need for safety when loading props are used, since they are apt to spill the load if mishandled or bumped by the lumber truck. As the lumber comes from the mill it is placed on the props, one size to a prop. The prop is just high enough so that the vehicle's rear bunk contacts the load about an inch ahead of the prop, the prop itself being about one-third the length of the load from the high or loading end. The load is then easily manhandled onto the vehicle which transports it to the drying yard.

PILING AND SORTING LUMBER FOR AIR DRYING

The degree to which it is practical to improve air-drying practices varies from mill to mill. In general, the larger the mill, the more exacting its practices, such as piling of stock according to species, grade, thickness, length, and width. Permanent mills can also do more in improving drainage, grading, and pile foundations.

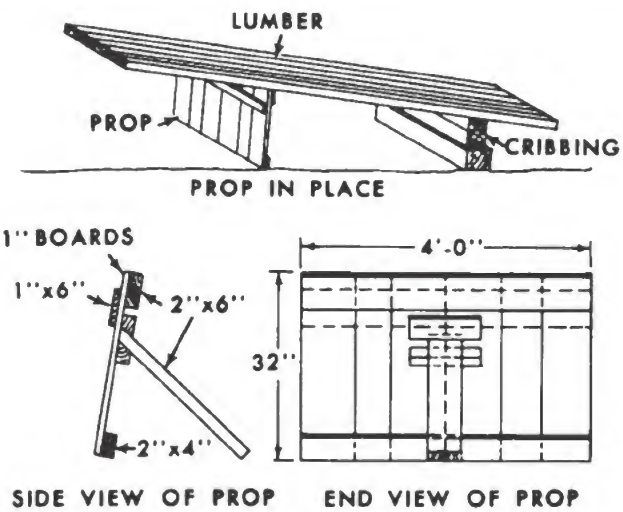

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Figure 7-37.— Lumber props.

The total number of piles necessary for a given operation depends upon production rates and seasoning time allowed, as well as demand. The total number of piles open, or in the process of building, at one time depends mainly on how closely the lumber is segregated according to species, size, and grade.

Each yard operator must determine the degree of segregation needed. Different thicknesses are, in general, separately piled. Hardwoods of different lengths and widths are usually placed in the same pile and may be separated according to grade. A common practice at small hardwood mills is to pile No. 1 common and better separately from No. 2 common and poorer.

Labeling of piles as to contents helps in identification and inventories. It can be done by surfacing the edge of a sticker (flat piece or strip used to separate layers or courses) with a knife and writing with a soft crayon the pile number, species, item (width, thickness, and grade), piling data, and footage. The footage is an estimate made either when the pile is completed or at the first inventory afterward.

PILE FOUNDATIONS

The foundations should be mechanically strong, and sufficient to raise the first course of lumber at least 18 inches from the ground. Piers, posts, or blocks make a more satisfactory foundation support than cribbing because the foundation is more open for air movement beneath the pile. For permanent yards, piers of concrete or masonry, or posts that are of a decay-resistant species or pressure-treated with a preservative, make excellent supports. Piers or posts set into firm ground should extend below the frost-line. Posts or blocks may rest on sleepers or mud sills placed on a soft ground surface. At portable operations a reasonably sound log or low value can be cut into sections to provide posts or blocks. The tops of each pair of supports should be surfaced or cut so that they are on a level crosswise, and are on a slope of 1 inch to the foot or on a level in a lengthwise direction.

The rest of the foundation consists of stringers and crossbeams, or of crossbeams only. Stringers, generally 6 to 8 inches in dimension laid on edge, are placed on tops of the piers, posts, or blocks. The stringers run lengthwise of the pile and follow the slope. Crossbeams, generally 4 by 4 or 4 by 6 inches in dimension, are laid on the stringers, or on the top of the posts, piers, or blocks where stringers are absent. Where stringers are used, the number of piers, posts or blocks can be reduced. Stringers also permit more flexibility in the positioning of the crossbeams so that with piles of different lengths, the crossbeams can be placed to support the vertical tiers of stickers.

Foundations for unit-package piles are usually level in both directions. Stringers cannot be used except where the rows of piles consist of two piles only. A satisfactory foundation for unit-package piles consists of crossbeams 4 feet apart supported by piers, posts, or blocks. A central 8-foot space is left clear for the entrance and exit of the forklift truck by omitting the central crossbeam. A removable and replaceable device carrying a crossbeam or its equivalent should be used to support the center of the pile. This support is put in place when the particular pile is made, but is removed to allow the forklift truck to approach piles nearer the center of the row. Such a support may be a sawhorse or a crossbeam with legs.

PILE CONSTRUCTION

For air drying, it is almost universal practice to pile stock flat, so that most of the weight bears on the wide faces, not on the edges or ends. A flat pile may be level both crosswise and lengthwise. With this method of piling the drying rate is relatively slow, but the weight of the pile tends to keep the stock from warping. It is, therefore, suited to species that are likely to suffer from sap stain. Flat piles may be

hand-stacked in a continuous pile from bottom to top or may be made up of several unit packages separated by bolsters. Hand-stacked piles may be square at both ends, such as a box of sorted length pile, or the board ends may project or overhang at the rear or at both ends. To prevent excessive warp, it is desirable either to sort for length or to box pile so as to eliminate overhanging ends.

For lumber that is susceptible to sap stain, special piling methods that promote rapid partial drying are sometimes used. These are known as end piling (A, fig. 7-38), end racking (B), and crib piling (C).

To obtain rapid drying with end piling wide spaces should be left between boards. End piling, though easily done by one man, causes nonuniform drying from top to bottom, and severe end checking and surface checking in the upper parts of the boards, particularly in thick stock. End racking causes rapid drying, with excessive checking and warping. Since the drying is for the purpose of getting the stock dry enough to prevent the fungus-caused discoloration known as blue stain, the stock should be piled flat to minimize checking and warping, when sufficiently dry. This will be from 30 to 45 days in most cases, depending on the temperature and weather. End-racked boards, however, are likely to blue stain where they cross. Crib piling also induces fast drying and is, therefore, useful for partial drying, but may result in excessive stain where the boards cross, as well as warping. Additional information on end

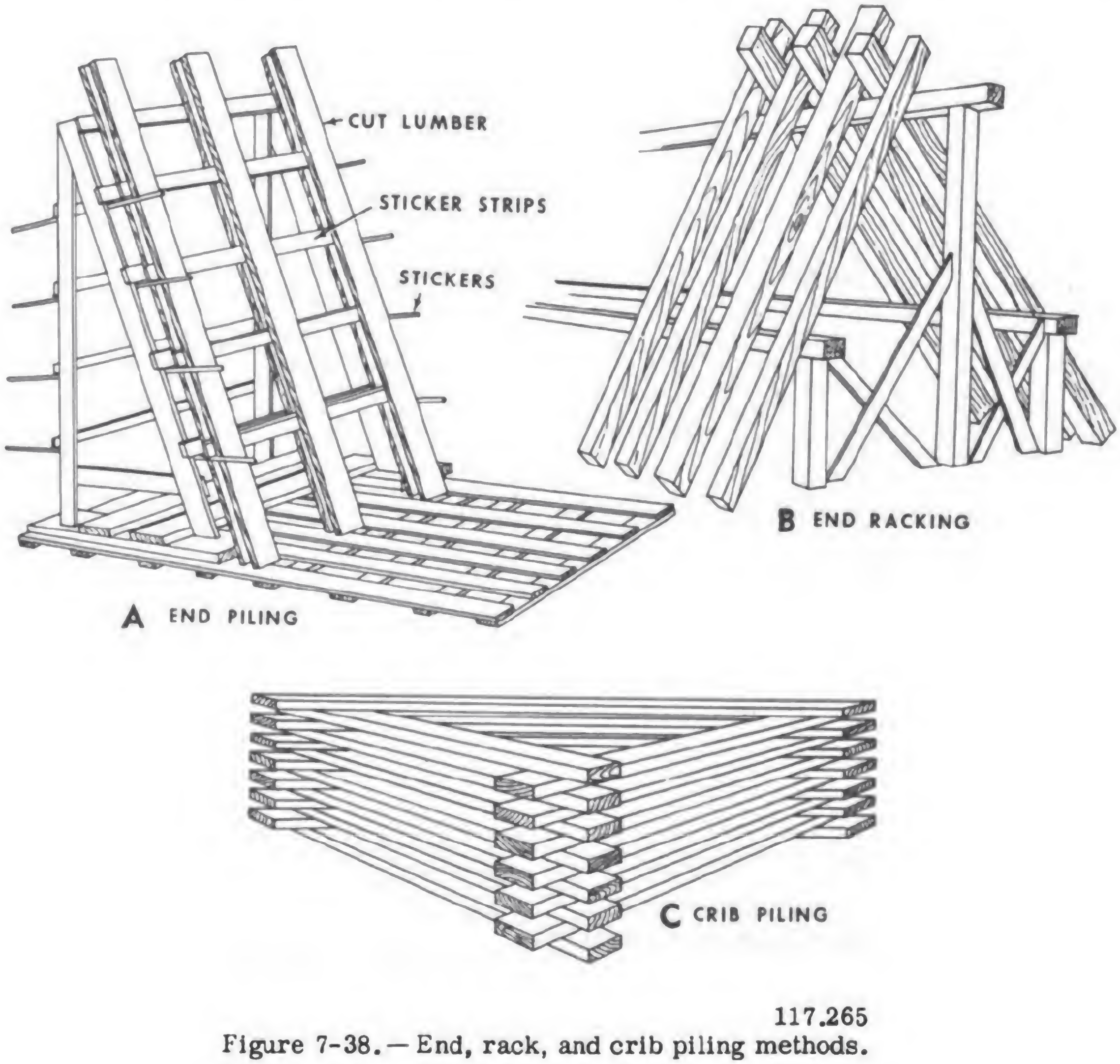

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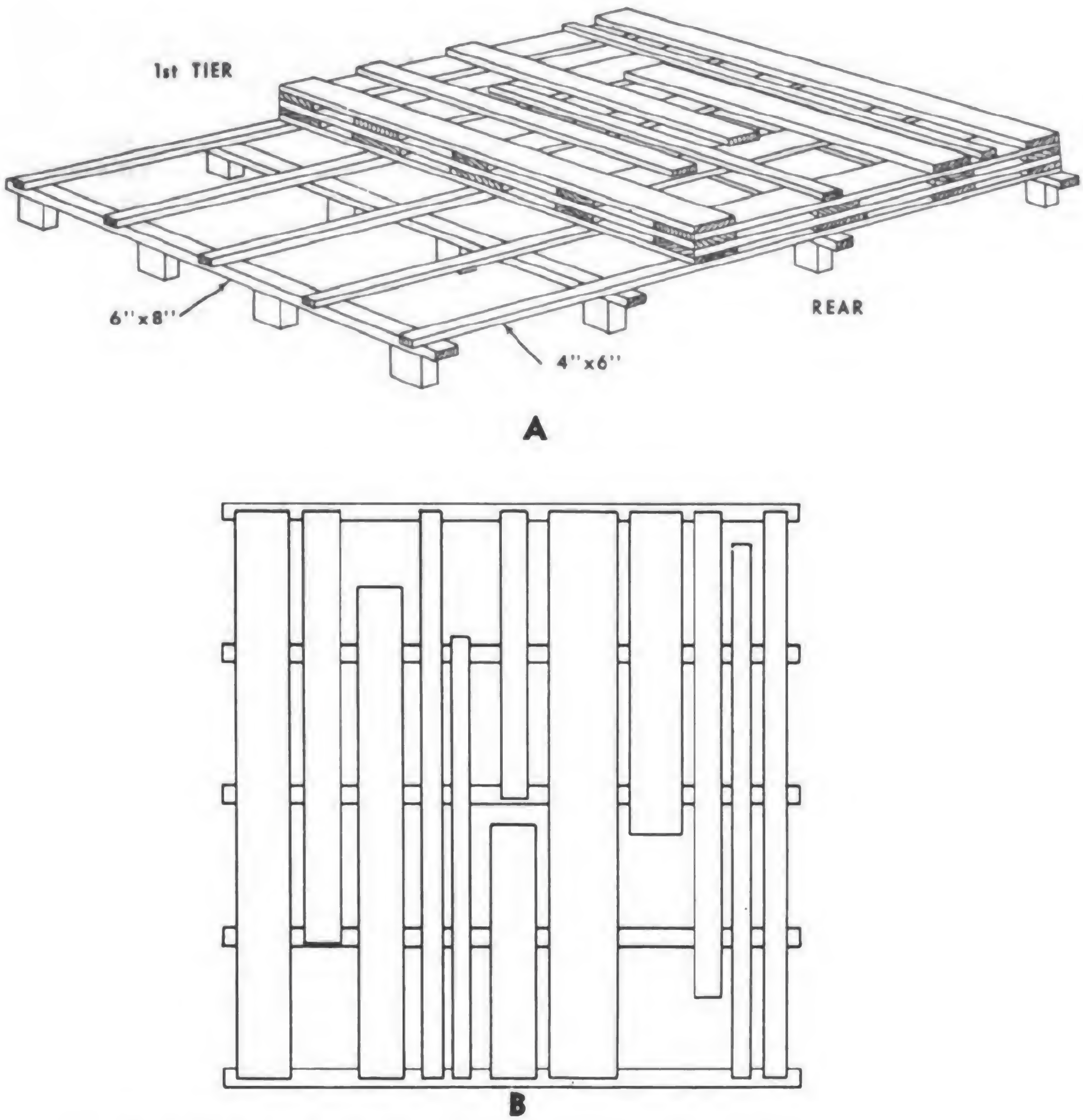
Figure 7-38.—End, rack, and crib piling methods.

piling, end racking, and crib piling is given later in this chapter.

BOX PILING

Box piling is recommended for hardwoods. To make a box pile (A, fig. 7-39), lay a sticker over each foundation crossbeam and place a full-length board in each of the outside tiers. If enough stock is available for more than two full-length boards to the course, intersperse long boards regularly in the course (B, fig. 7-39). Place shorter boards in the inside tiers, with their ends alternately flush with the front and



A. Method of laying on foundation
B. Top view showing board placement according to length

117.266
Figure 7-39.— Method of placing boards in box piling.

back of the pile. Each tier is approximately 12 inches in width; thus it can contain an 8- and a 4-inch board, or two 6-inch boards. One end of each board can rest on the sticker at either end of the pile. Tiers should be truly vertical, 4 to 6 inches apart. The front of the pile should be given a pitch of 1 inch per foot of height. This method of piling results in vertical flues that allow a free downward air flow from the top to the bottom of the pile. Both ends of the pile should be square with no projecting board ends.

SORTED-LENGTH PILING

Sorted-length piling which closely resembles box piling, is recommended for softwoods. To make such a pile, lay a sticker over each crossbeam and place the first course of boards so that the front end of each board is flush with the front edges of these stickers. Space the boards in this course 2 to 3 inches apart; if two or more lengths are included in the same pile, place the longest ones in the outside tiers, and intersperse other long ones regularly in the course to give a well supported pile. Succeeding courses duplicate the first or base course.

The front of the pile should pitch toward the main alley, 1 inch to the foot of height. Each tier of stickers within a tier should be aligned parallel to the front one. Stickers within a tier should be directly above one another except for the slight progressive offset required to follow the pitch of the pile. The front of the pile should be free of projecting ends that would catch water and cause it to flow into the pile. If the boards are of uniform lengths and the piling has been well done, the rear of the pile will also be free of projecting ends.

UNIT-PACKAGE PILING

Unit-package piles are composed of from three to five unit packages, placed by forklift truck. The unit packages are made up at the rear of the mill, using methods similar to those recommended for flat piling. They are hauled to the yard by forklift truck and built into piles. Good sticker alignment and uniform spacing are essential in unit packages of lumber in order to obtain good alignment of crossbeams, bolsters, and tiers of stickers in the yard pile of unit packages. Piles of unit packages do not ordinarily have either slope or pitch.

STICKERS

Stickers are used to separate the courses of lumber in a pile. Stock stickers are narrow boards of the same lumber as the pile. Such piles are commonly called self-stickered. Self-stickering may be justified with a low-value lumber, where degrade suffered through staining and checking is not important. Special stickers for lumber up to 3/8-inch thickness are generally made of nominal 1-inch stock, rough or dressed. Stickers for thicker lumber may be about 1-1/2 inches thick. Special stickers for hardwoods are generally about 1 inch thick by 1-1/2 to 2 inches wide, and for softwoods 1 by 2 or more inches. Special stickers should preferably be of air-dried heartwood. At small portable mills, edgings that have been air-dried provide relatively cheap and satisfactory stickers. Stickering of unit packages of lumber follows the same rules as stickering of hand-stacked piles except that the narrow width of the packages rules out the use of stock for stickers.

PILE ROOFS

If yard piles are not roofed the upper courses of lumber are likely to deteriorate enough to cause a drop in grade. The roof should protect the pile from sunshine and precipitation and should be reasonably tight. A common type of pile roof is one composed of a double layer of grade boards. The roof should be pitched so that most of the water will run to the rear end and drip off. If the lumber pile slopes 1 inch per foot from front to rear, the pitch of the roof can follow the slope of the pile. If the pile is not sloped, the roof should be supported so as to obtain the required pitch.

For a sloped pile, the front roof support can be made by placing three 2 by 4's laid flat with the center and rear supports made up of 2 by 4's. A double layer of boards is laid on the center and rear supports with the boards of the upper layer overlapping those in the lower layer. This procedure is repeated for the front part allowing this part of the roof to overlap the rear portion. The roof should project beyond the pile about 1 foot at the front and 2-1/2 feet at the rear. In windy regions, tie pieces wired to the pile should be placed at the front, center, and rear to keep the roof boards from blowing off.

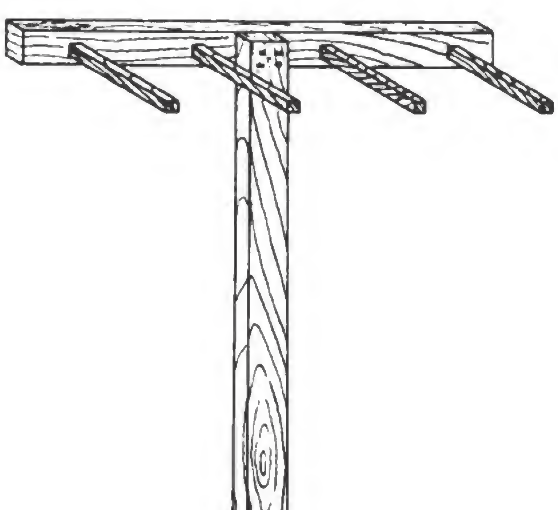
END PILING

Lumber piled on end is equivalent to an upended flat pile. Boards for end piling (A, fig.

7-38) should be grouped according to length. With random-width stock, like widths should be placed in the same row or upended tier. In its simplest form, end piling requires a floor, a central rack, and strips or some other device to support the stickers.

The stickers must be placed and held until the two outer boards of a course are placed. Strips for supporting stickers can be dispensed with if the piler is provided with a sticker holder (fig. 7-40), consisting of a handle adequate to reach the height desired for placing the sticker and one or more crossarms each approximately 3 feet long. The sticker resting on the crossarm is easily boosted into place. Then, while the handle end of the tool is supported on the base, the piler places the outside boards of the next course against the sticker, thus permitting removal of the holder.

The floors should be of latticed construction and should support the lumber at least a foot above the ground. The central rack should be sturdy. Piles are generally built up on two directions from the rack, but occasionally in one direction only. The piles are usually about 10 feet wide and 75 to 100 feet long, with an 8-inch space between the rows of boards.



117.267
Figure 7-40.—Sticker holder.

END RACKING

In end racking, two rows of boards placed on end are crossed like an X, or preferably form an inverted V (B, fig. 7-38). The boards are supported by a ridge pole, and the lower ends should be supported about a foot above the ground. Since the boards will cross at their top ends in order to support each other in an upright position, different racks will be needed for different length stock.

The stock dries rapidly; 3 to 15 days of drying, depending on the weather, should be sufficient to prevent staining. After this period the lumber should be flat-piled or shipped to prevent excessive checking and warping in the end-racked pile.

CRIB PILING

Crib piling, used by some small mills cutting southern pine, eliminates foundations, stickers, and pile roofs but requires excessive yard space. Separate piles are made for each length by cribbing three tiers in the form of a triangle (C, fig. 7-38). The first plank rests on supports at each end; one end of the second plank crosses the first above a support and the other end rests upon the third support of the triangle; and the third plank closes the triangle. In succeeding courses this crib rack is carried to a height convenient for one-man stacking. The drying rate is like that of end-racked lumber; if excessive checking and warping are to be avoided, the cribbed lumber should be taken down and flat-piled after 3 to 15 days.

REFINEMENTS IN FLAT-PILING PRACTICE

In flat-piles, the drying rate and consequent degrade by blue stain, decay, checking, and warping are likely to vary with the location of the pile, the species of wood, and the season. Therefore, where there is need to reduce such undesirable effects, the following refinements in piling may be considered.

To reduce checking:

1. Lower the foundations; decrease the spacing between boards and between piles.

2. Use thinner, narrow stickers. Place end stickers so that they project beyond ends of the pile.
3. Use end coatings.
4. Shield from sun and wind by piling in abandoned buildings where available.

To reduce blue stain and decay occurring throughout the pile:

1. Raise the foundations; increase the spacing between boards and between piles.
2. Provide one central flared chimney or a series of narrow chimneys. Chimneys are formed by leaving boards out of each course in such a way that a vertical opening is left from the top to the bottom of the pile.
3. Narrow the piles.

SAFETY IN YARD OPERATIONS

Personnel handling rough-sawn lumber should wear heavy leather gloves to protect their hands against splinters.

Lumber should not be stacked without a proper foundation.

Lumber stacked too high is hazardous in that it is easily blown or pushed over.

Smoking should not be allowed in the lumberyard.

First aid and firefighting equipment should always be available for use by any personnel working in the lumberyard.

Personnel should be prohibited from riding as passengers on materials handling equipment.

All trash and vegetation should be cleared away from lumber stacks.

CHAPTER 8

HEAVY CONSTRUCTION

In the broad sense, heavy construction means any construction which involves the use of massive, large-dimension structural members or large quantities of heavy materials. Consequently, the chapter on heavy construction in Builder 3 & 2 discusses not only heavy timber construction, but also heavy stone and concrete construction in waterfront structures such as piers, breakwaters, jetties, and groins.

Most heavy timber construction for Seabees consists of trestle bent construction for timber trestle bent bridges or pile bent construction for timber piers. Nomenclature of structural members and general methods of construction for both of these types of construction are explained in Builder 3 & 2.

This chapter covers tower and trestle bent layout methods, plus further treatment of construction methods. Information is also provided on the use of tower and longitudinal sash bracing in trestle construction. We will also explain methods used for straightening, cutting, and driving pile in the construction of a timber waterfront structure. The instructions in this chapter should be useful as a guide in directing various operations involving heavy construction.

TRESTLE BENT LAYOUT

For each bent in a trestle the lengths of the posts must be determined separately. Although the deck elevation is the same throughout for most trestle bent bridges, the lengths of the posts for a particular bent will depend on the sill elevation at that bent.

Consider the trestle bent shown in figure 8-1. Given here are the width of the roadbed between the curbs (20 ft), the deck elevation (306.22 ft), and the post batters. This is a 5-post bent; we'll refer to the piles as CENTER (no batter), INNER (1 in 12 batter), and OUTER (2 in 12 batter). Assume that given dimensions for structural members are as follows:

Member	Section Dimensions in Inches
Decking	4 x 12
Stringer	6 x 14 (on edge)
Cap	12 x 14 (on edge)
Post	12 x 12

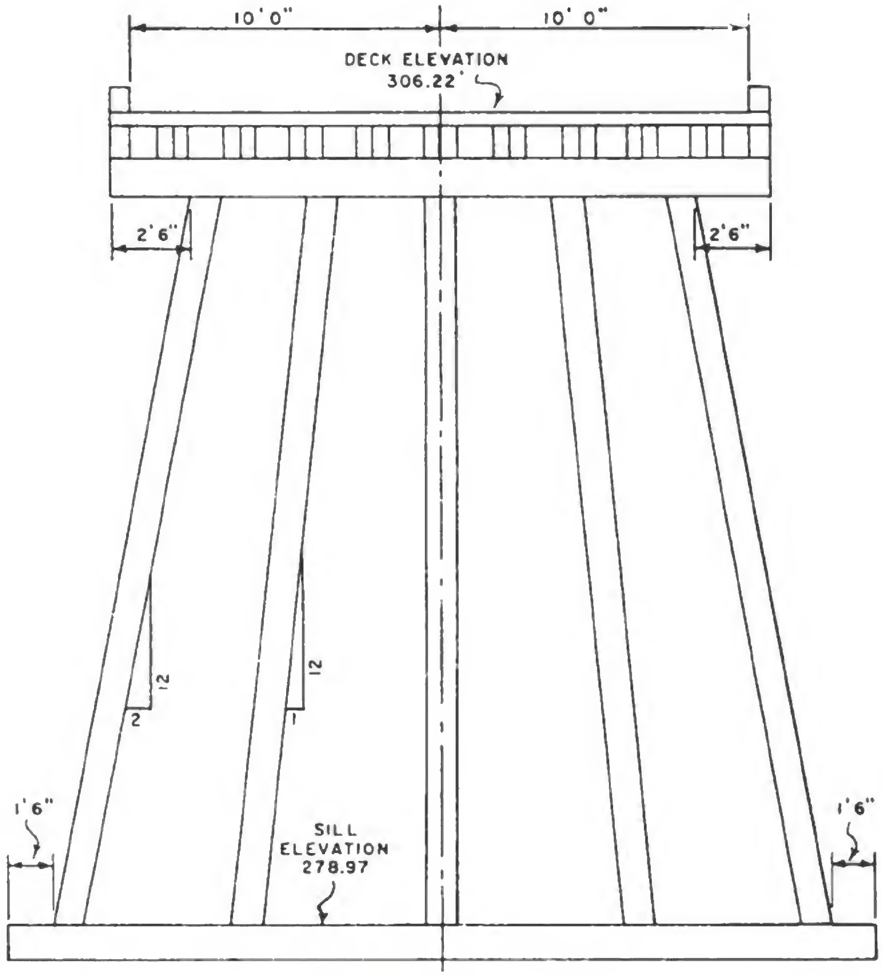
Assume that these are unfinished timbers, in which the nominal dimensions are the same as the actual dimensions.

POST LAYOUT

The vertical distance to be covered by a post in this bent equals the difference between the deck and the sill elevations, less the sum of the thickness of the decking (4 in.), plus the depth of a stringer (14 in.), plus the depth of cap (14 in.). This sum is 32 in., or 2 ft 8 in. The difference between the deck and the sill elevation is 306.22 ft minus 278.97 ft, or 27.25 ft, or 27 ft 3 in. Therefore the vertical distance to be covered by a post (which we'll call the VERTICAL POST RISE) is 27 ft 3 in. minus 2 ft 8 in., or 24 ft 7 in. Because the center post has no batter, the length of that post will be equal to the vertical post run, or 24 ft 7 in.

The length of an inner and an outer post, however, must be computed. The best way to approach the problem is to consider one of these posts just as you would a common rafter. Let's figure the length of an inner post first.

This length is the same as the length of a common rafter would be with unit run 12 in., unit rise 1 in., and total run 24 ft 7 in. Twenty-four feet seven in. equals 24.58 ft. From framing square tables, or by extracting the square root of $12^2 + 1^2$, you find that the unit length of one of these posts is 12.04 in. for every unit of run, which is the same as 1.003 ft. Therefore, the



117.107
Figure 8-1.— Trestle bent.

total length of an inner post equals 1.003 times 24.58 ft. or 24.66 ft, or 24 ft 8 in.

For the end cuts, set the framing square to batter as shown in figure 8-2.

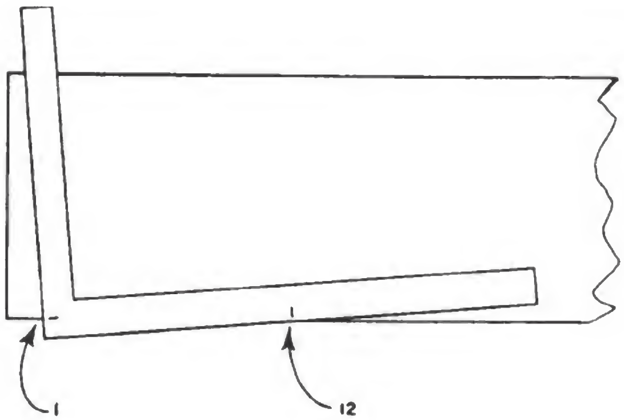
The length of an outer post is the same as the length of a common rafter would be with unit run 12, unit rise 2, and total run 24.58 ft. From framing square tables, or by working the square root of $12^2 + 2^2$, you find that the unit length of one of these posts is 12.16 in. for every 12 unit of run, which is the same as 1.013 ft. Therefore, the total length of an outer post equals 1.013 times 24.58 or 24.90 ft, or 24 ft 10-3/4 in.

For the end cuts, set the framing square to the batter as shown in figure 8-3.

CAP AND SILL LAYOUT

You can see in figure 8-1 that the length of a cap equals the width of the roadbed (20 ft) plus twice the width of a curb. Suppose the curbs to be 8 x 10's on edge. Then twice the width of a curb is 2 x 8, or 16 in., or 1 ft 4 in. The length of the cap is therefore 21 ft 4 in.

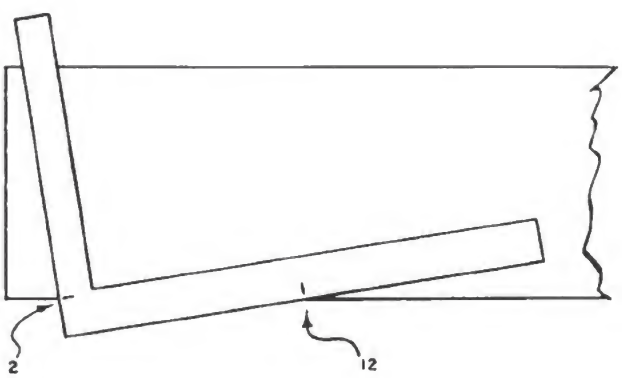
All that figure 8-1 tells you about the sill is the fact that it must extend 1 ft 6 in. beyond the outer post on each side. You know that, if this post were plumb (vertical), the outer face of the post would be located on the sill directly below the location of the outer face of the post on the cap. The distance from the center line to the outer face of the post on the cap is equal to



117.108
Figure 8-2.—End cut for inner post shown in figure 8-1.

half the length of the cap minus 2 ft 6 in. Half the length of the cap is 10 ft 8 in.; this minus 2 ft 6 in. is 8 ft 2 in.

Next you must determine how far the outer face of the post is to be offset from vertical position because of the batter. The offset is 2 in. for every unit of run. The run is 24 ft 7 in., or 24.58 ft. Therefore, the offset equals the value of x in the equation 2:12::x:24.58, or 4.1 ft, or 4 ft 1-1/4 in. The distance from the center line to the outer face of the post on the sill will be the sum of 8 ft 2 in. plus 4 ft 1-1/4 in., or 12 ft 3-1/4 in. The distance from the center



117.109
Figure 8-3.—End cut for outer post shown in figure 8-1.

line to the end of the sill will be 12 ft 3-1/4 in. plus 1 ft 6 in., or 13 ft 9-1/4 in. The length of the sill will be 2(13 ft 9-1/4), or 27 ft 6-1/2 in.

To locate the outer face of an inner post on the cap and the sill the computations are similar. Assume that on the cap the outer face of the inner post is to be located half-way between the face of the center post and the outer face of the outer post. The outer face of the outer post lies 8 ft 2 in. from the center line. The outer face of the center post is 6 in. (half the width of the post) from the center line. The distance between the faces, then, equals 8 ft 2 in. minus 6 in., or 7 ft 8 in. Half of this is 3 ft 10 in. Therefore, the distance from the center line to the outer face of an inner post on the cap is 3 ft 10 in. plus 6 in., or 4 ft 4 in.

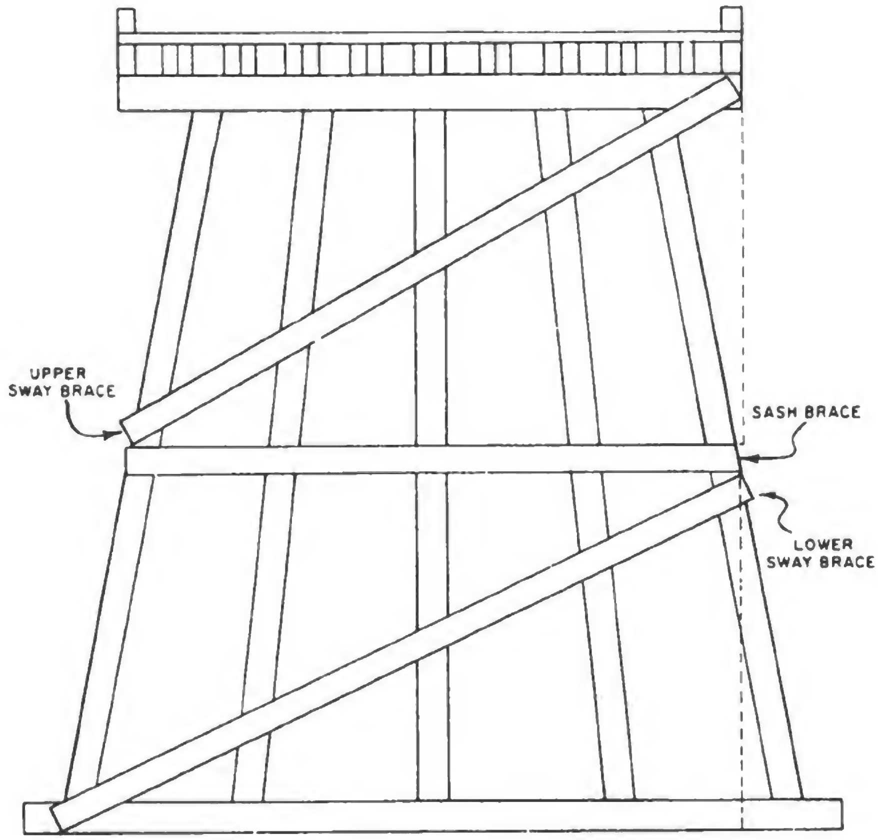
Again, if the inner post were plumb, the outer face would lie on the sill directly below the outer face on the cap. You must figure the offset for a 1 in 12 batter. This equals the value of x in the equation 1:12::x:24.58, or 2.05 ft, or 2 ft 5/8 in. Therefore, the distance from the center line to the outer face of an inner post on the sill will be 4 ft 4 in. plus 2 ft 5/8 in., or 6 ft 4-5/8 in.

BRACE LAYOUT

Suppose that the bent shown in figure 8-1 is to be braced with a transverse SASH (horizontal) brace, located midway between the top of the sill and the bottom of the cap, and upper and lower SWAY (transverse diagonal) braces, as shown in figure 8-4. We'll figure the length of the sash brace first.

If you study figure 8-4, you will realize that one-half the length of the sash brace must equal the average between (1) the horizontal distance from the center line to the outer face of the outside post on the cap, and (2) the horizontal distance from the center line to the outer face of the outside post on the sill. Distance (1) is 8 ft 2 in.; distance (2) is 12 ft 3-1/4 in.; therefore, half the length of the sash brace is the average between these, or 10 ft 2-5/8 in. The whole length of the sash brace is twice this, or 20 ft 5-1/4 in.

Next we'll figure the length of the lower sway brace. If you study figure 8-4, you will see that this brace forms the hypotenuse of a



117.110

Figure 8-4. — Transverse bracing for bent shown in figure 8-1.

right triangle. The horizontal side of this triangle is made up of lengths as follows:

The horizontal distance from the center line to the outer face of the outside post on the sill	12 ft 3-1/4 in.
Plus:	
Half the length of the sash brace	10 ft 2-5/8 in.
	22 ft 5-7/8 in.

You can call that 22 ft 6 in. or 22.5 ft. The length of the vertical side of the triangle equals one-half the vertical rise minus the width of the sash brace, or 12 ft 3-1/2 in. minus 5 in., or 11 ft 10-1/2 in., or 11.9 ft.

By the Pythagorean theorem, the length of the hypotenuse (which equals the length of the lower sway brace) equals the square root of $(22.5^2 + 11.9^2)$, or the square root of 647.86, which comes to 25.45 or 25 ft 5-1/4 in.

The upper sway brace likewise forms the hypotenuse of a right triangle. The length of the horizontal side of this triangle equals half the length of the sash brace plus half the length of the cap, or 10 ft 2-5/8 in. plus 10 ft 8 in., or 20 ft 10-5/8 in. You can call this 21 ft. The length of the vertical side of the triangle equals half the vertical rise, minus half the width of the sash brace, plus about 4 in. for overlap on the cap (estimated); or 12 ft 3-1/2 in. minus 5 in. plus 4 in.; or 12 ft 2-1/2 in., which is about 12.2 ft.

The length of the hypotenuse (which equals the length of the upper sway brace) equals the square root of $21^2 + 12.2^2$), or the square root of 589.84 which comes to 24.3 ft, or about 24 ft 4 in.

TOWER LAYOUT

Tower members are laid out just as trestle bent members are laid out, except in the case

of a tower in which the corner posts have a two-way batter.

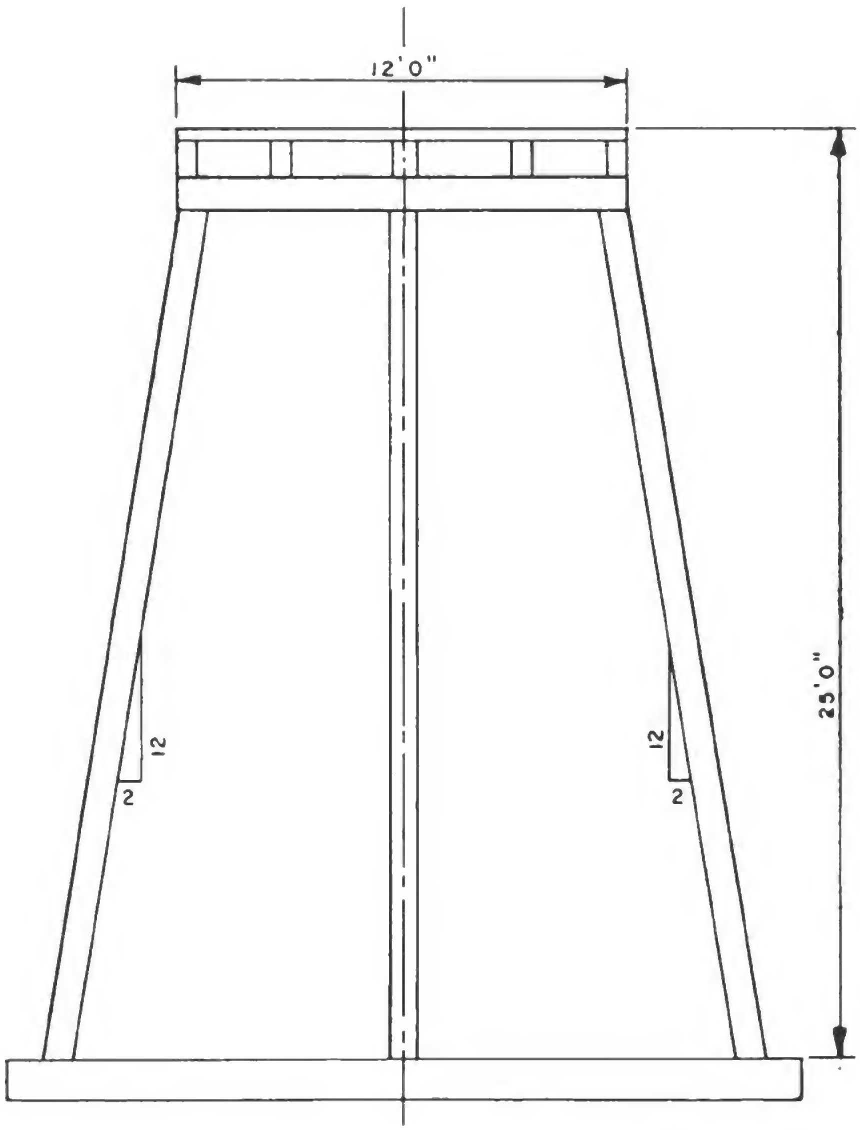
Figure 8-5 shows a girder-end elevation, and figure 8-6 a side elevation, of a tank tower. You can see that the center posts in each outside bent are battered in only one direction; therefore, you figure the lengths of these posts just as you previously figured the lengths of inner and outer posts for the trestle bent.

However, you can see that the corner posts in each view are battered in two directions. Figuring the length of one of these is similar to figure the length of a hip or valley rafter.

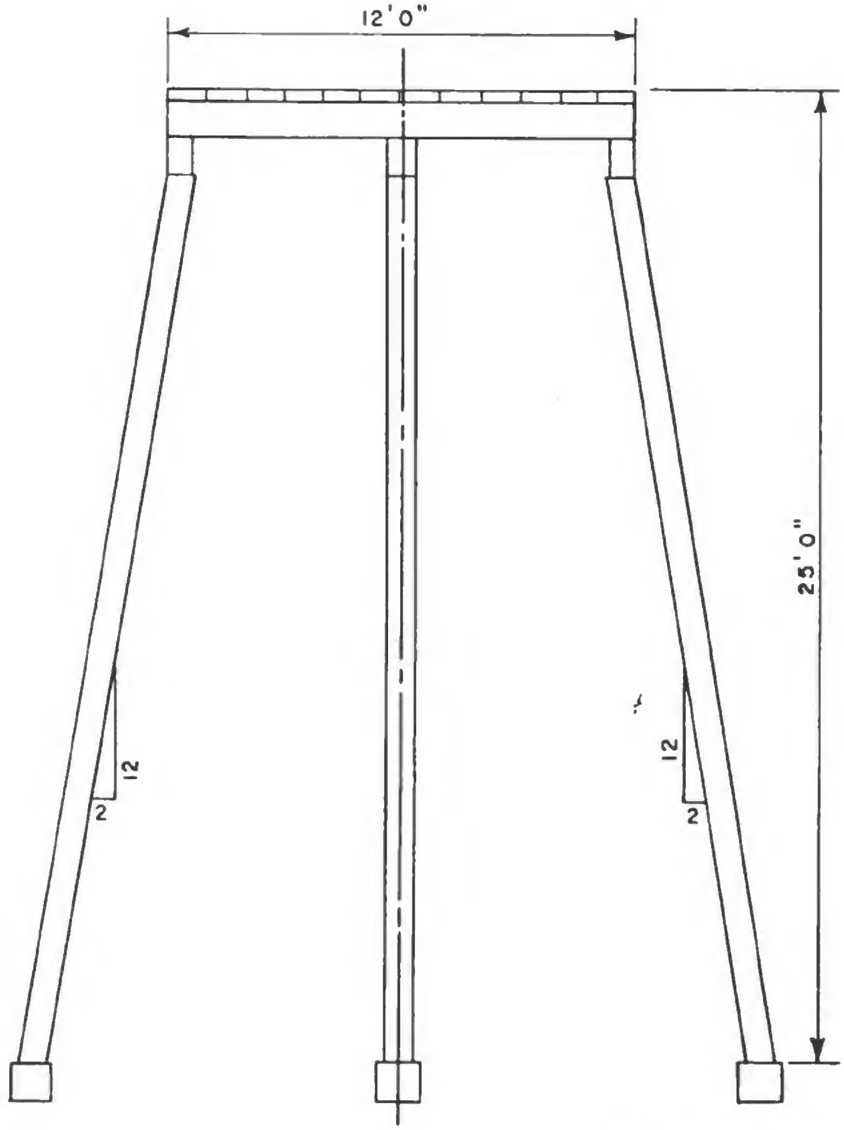
Let's assume that member section dimensions in inches for this tower are as follows:

Deck plank:	2 x 12
Girder:	2 x 10 (on edge)
Cap:	8 x 12 (on edge)
Post:	8 x 8

The total vertical rise for a post equals 25 ft (vertical distance from sill to deck surface)



117.111
Figure 8-5.—Girder-end elevation of tank tower.



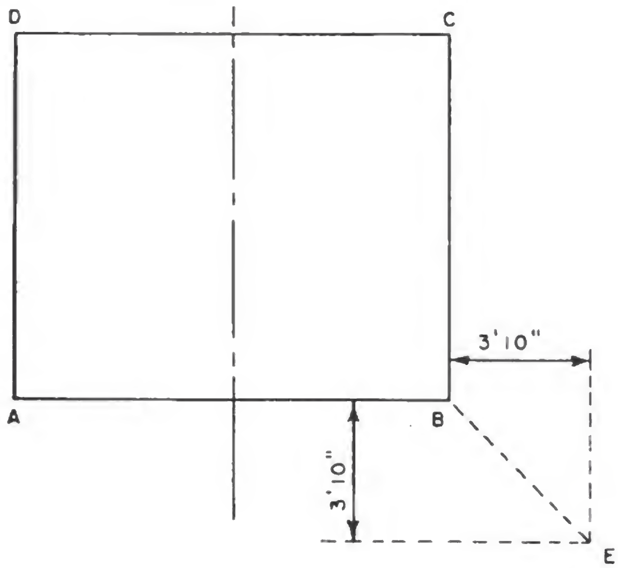
117.112
Figure 8-6. — Side elevation of tank tower.

minus the sum of the thickness of a deck plank plus the depth of a girder plus the depth of a cap. This sum is 2 in. + 10 in. + 12 in., or 24 in., or 2 ft. Therefore, the total vertical run for a post is 25 ft minus 2 ft, or 23 ft.

Next you figure the offset each way for the batter. The batter is 2 in 12; therefore, the offset each way equals the value of x in the equation 2:12::x:23, or 3.83 ft., or 3 ft 10 in.

Now take a look at figure 8-7. The square ABCD represents a plan outline of the deck of the tower. If you look at corner B, you will see that, for a two-way batter of 3 ft 10 in., the total offset for a corner post will equal the length of the line BE. This line is the hypotenuse of a right triangle with sides each 3 ft 10 in., or 3.83 ft, long. Therefore, the length of BE (that is, the total offset of a corner post) equals the square root of $3.83^2 + 3.83^2$), or the square root of 29.34, or 5.4 ft, or 5 ft 5 in.

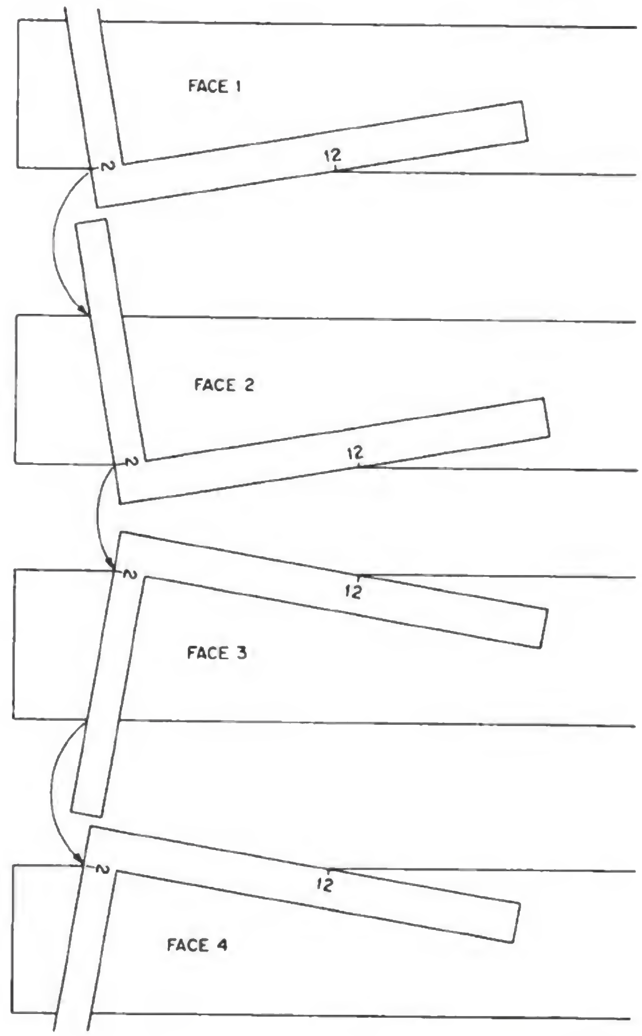
Now, if you think about it for a minute, you will realize that the length of a corner post



117.113
Figure 8-7.—Plan outline.

equals the length of the hypotenuse of a right triangle with one side equal to the total vertical rise of a post and the other equal to the total offset. The total vertical rise is 23 ft; the total offset is 5.4 ft. Therefore, the length of the hypotenuse equals the square root of $(23^2 + 5.4^2)$, or the square root of 558.16, or 23.6 ft, or 23 ft 8 in. This, then, is the length of one of the two-way-batter corner posts.

You lay out an end cut for one of these posts as shown in figure 8-8. As you can see, you lay off the batter on each of four successive faces with the framing square, picking up on each face where you left off on the previous face. You then run a line all the way around and cut to the line as shown in figure 8-9. Be very careful to lay off on the same faces at the upper end.



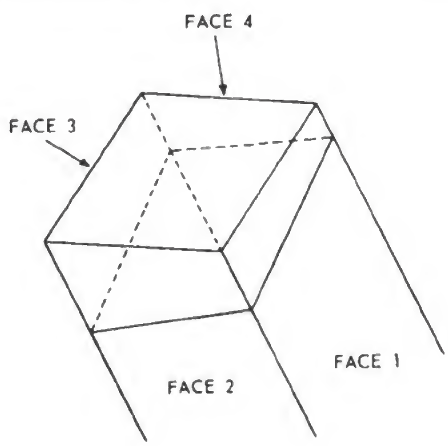
117.114
Figure 8-8.—Laying out end cut for corner post with two-way batter.

TRESTLE CONSTRUCTION

The way you put up a trestle will depend to some extent on how high it is and the equipment you have. If you have a crane available which can hoist an assembled bent into place on the sill, you can assemble cap, posts, and bracing for the bent on the ground, which is a lot easier than assembling upright.

TRESTLE ERECTION

In the discussion on trestle erection below, it is assumed that no crane capable of handling an assembled bent is available. It is likewise assumed that bent members and bracing are all laid out and cut, and that the footings for the sills are already in place. The trestle is to be one with bents as shown in figures 8-1



117.115
Figure 8-9.— End cut for corner posts with two-way batter.

and 8-4—that is, with 5-pile bents with outer and inner posts battered and center post plumb.

1. Install the sill. Methods and devices for joining heavy timber construction members are described in Builder 3 & 2.

2. Raise, plumb, temporarily brace, and attach the center post.

3. Raise inner and outer posts to approximate batter angles, and brace temporarily to center post and to each other. Bring bases to marks on sill and join.

4. Set cap on posts with center post to mark and attach center post to cap.

5. Bring other posts to the cap marks and attach.

6. Attach permanent sway and transverse sash bracing.

7. Plumb the bent longitudinally and brace temporarily.

8. Attach permanent tower and longitudinal sash bracing. This bracing is discussed in the next section.

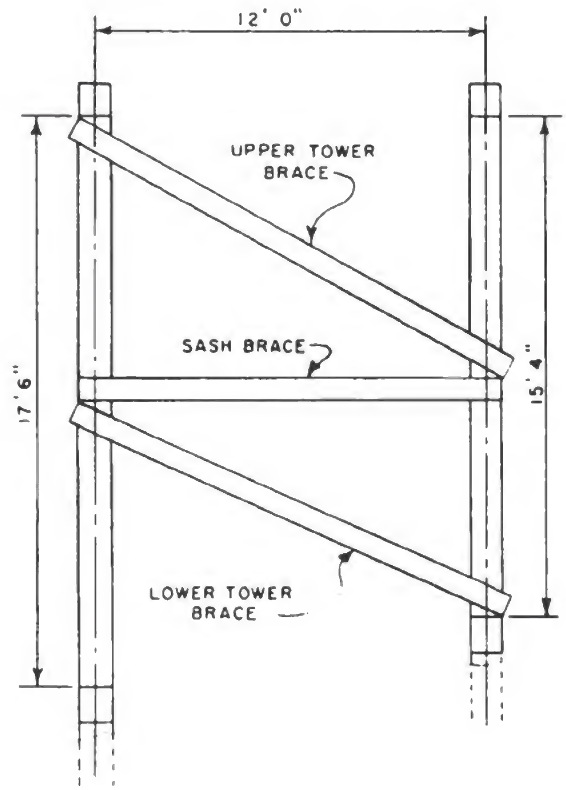
9. Place stringers and decking.

TOWER AND LONGITUDINAL SASH BRACING

The longitudinal diagonal bracing which braces a bent to the abutment or to an adjacent bent is called TOWER bracing. Horizontal bracing used for the same purpose is called LONGITUDINAL sash bracing. You figure the lengths just as you do for sway and transverse sash bracing.

Figure 8-10 shows a pair of bents braced by 2 in. x 5 in. upper and lower tower braces and a longitudinal sash brace. The longitudinal sash brace is located at the vertical mean midpoint of the bents—what you might call the average middle. The vertical mean midpoint is located as follows:

Half of the vertical post rise for the left-hand bent in figure 8-10 is one-half of 17 ft 6 in., or 8 ft 9 in. Half of the vertical post run for the right-hand bent is one-half of 15 ft 4 in., or 7 ft 8 in. The difference between these two is 13 in., and half of that is 6-1/2 in. Therefore, the vertical mean midpoint for the left-hand bent is 6-1/2 in. above the actual midpoint, or 8 ft 9 in. + 6-1/2 in., or 9 ft 3-1/2 in. above the sill. The



117.116
Figure 8-10.— Tower and longitudinal sash bracing.

vertical mean midpoint on the right-hand bent is 6-1/2 in. below the actual midpoint, or 7 ft 8 in. minus 6-1/2 in., or 7 ft 1-1/2 in. above the sill. The center line of the sash brace, then, would be located 9 ft 3-1/2 in. above the sill on the left-hand bent, 7 ft 1-1/2 in. above the sill on the right-hand bent.

The upper tower brace forms the hypotenuse of a right triangle with the horizontal side equal to the spacing of bents O.C plus the thickness of a post, or 12 ft plus 12 in., or 13 ft. The length of the vertical side equals the total rise of a post, less 5 in. more than the vertical distance from the sill to the sash brace center line, or 17 ft 6 in. minus (9 ft 3-1/2 in. plus 5 in.), or 7 ft 9-1/2 in., or 7.8 ft. The length of the hypotenuse (which equals the length of the upper tower brace) equals the square root of $13^2 + 7.8^2$), or the square root of 229.84, or 15.1 ft, 15 ft 1-1/2 in.

The lower tower brace forms the hypotenuse of a right triangle with the horizontal side again 13 ft long. The length of the vertical side is 5 in. less than the vertical distance from the sill to the sash brace center line on the right-hand bent, or 7 ft 1-1/2 in. minus 5 in., or 6 ft 8-1/2 in., or 6.70 ft. The length of the lower tower brace equals the square root of $13^2 + 6.70^2$), or the square root of 214.0, or 14.6 ft, or 14 ft 7 in.

TIMBER WATERFRONT STRUCTURES

A timber pier is constructed much like a timber trestle, except that the bents are PILE bents instead of post bents. You figure the lengths of piles much as you do the lengths of posts, except that you add to the computed length of each pile (1) the distance the pile is supposed to penetrate into the mud, and (2) 2 or 3 feet extra, for cutting waste as described later.

The load which must be carried by an individual pile or group in a foundation is dependent upon the structure concerned and the loads which it carries. Under normal circumstances, pile foundations are designed to support the entire dead load of the structure plus an appropriate portion of the line load; therefore, the load bearing capacity must be determined beforehand. In determining this load bearing capacity for timber or steel, using a double-acting pneumatic or steam hammer, you may use one of the formulas given below, as appropriate.

$$\text{Timber } P = \frac{2E}{(S + 0.1)} \qquad \text{Steel } P = \frac{3E}{(S + 0.1)}$$

In the above formulas:

P = Estimated safe capacity of pile (lb).
S = Average pile penetration, in inches per blow, for the last 20 blows.
E = Work energy in ft/lbs of hammer.

PILE DESIGNATIONS

Each pile in a pier is designated by a letter (which indicates the bent it is in) and a number. Figure 8-11, for example, shows how the piles in an advanced base timber pier would be designated. Bents are, as you see, lettered consecutively out from the shore; piles are numbered as shown. The piles at points F, D, and E would be piles F 16, F 17, and F 18.

The computed angles from the control stations to each pile are set down in PILE LOCATION SHEETS like the ones shown in figure 8-12. Shown here are the control angles for the piles located at F, D, and E (piles F 16, F 17, and F 18) in figure 8-11. "BS STATION" means "backsight station," or the point the transit is trained on which the horizontal circle is set at 0°. Under "REMARKS" is the direction (left or right) in which the angle is turned from the backsight.

CONSTRUCTING A PILE BENT

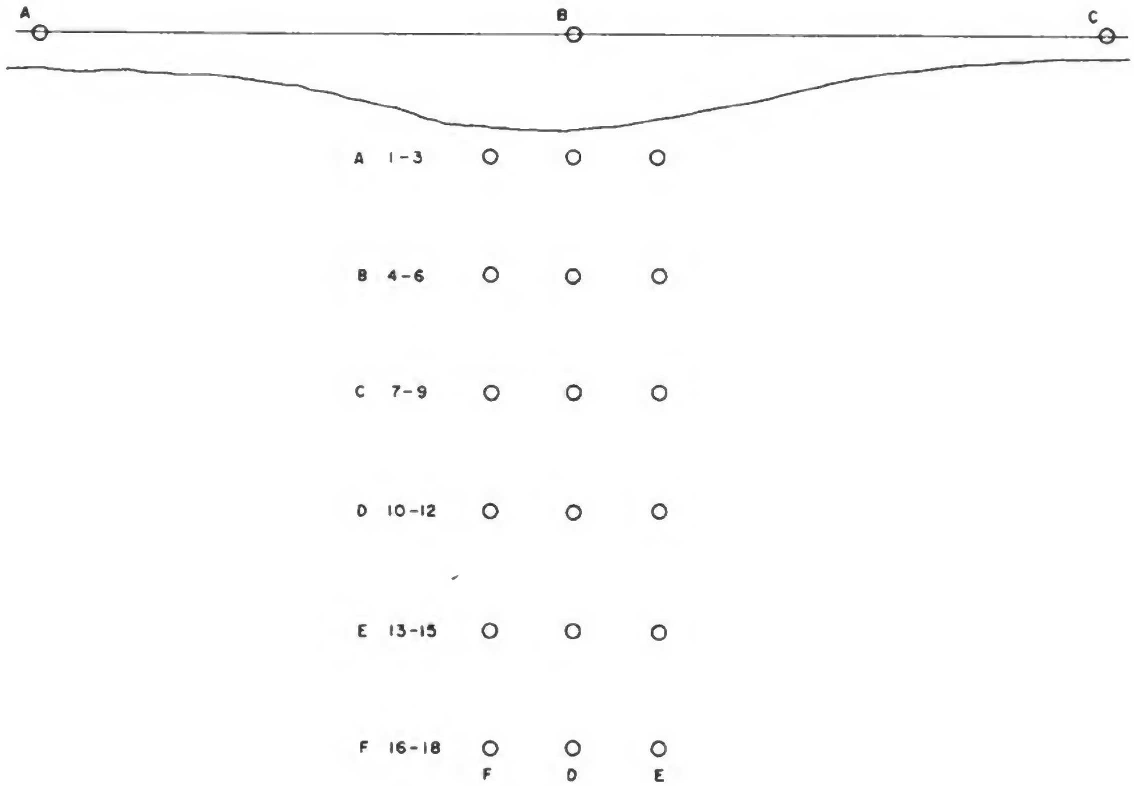
After the piles in a pile bent have been driven, the remaining steps in constructing the bent consist of STRAIGHTENING, CUTTING, CAPPING, and BRACING the piles.

Straightening Piles in a Bent

Piles in a bent are straightened with tackles and brought into alignment with a STRAIGHTENING FRAME, as shown in figure 8-13(B). After the frame has been put on, a WORKING PLATFORM like the one shown in figure 8-13(B) is usually erected, to support the men who will cut, cap, and brace the piles.

Cutting Piles in a Bent

A timber pile for a bent is selected long enough to leave 2 or 3 ft extending above the specified elevation of the bottom of the cap



117.117
Figure 8-11.—Pile designations.

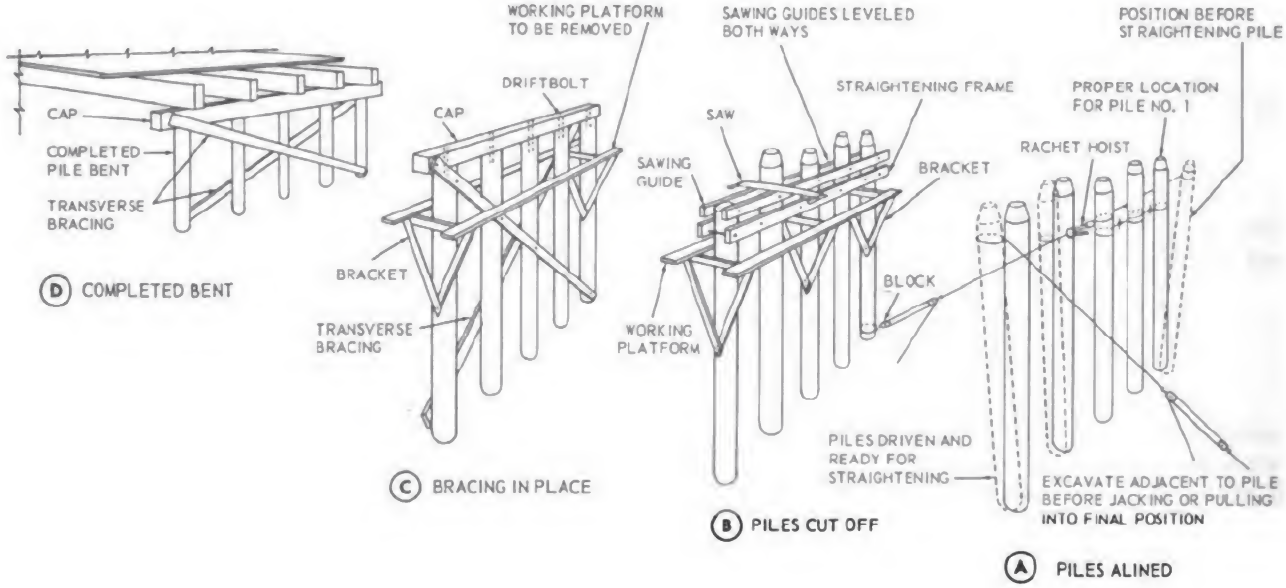
TRANSIT AT CONTROL STA. A				
BENT	PILE	BS STATION	ANGLE FROM BS	REMARKS
F	16	C	54° 22′	∠R
	17	C	50° 12′	∠R
	18	C	46° 12′	∠R

TRANSIT AT CONTROL STA. C				
BENT	PILE	BS STATION	ANGLE FROM BS	REMARKS
F	16	A	46° 12′	∠L
	17	A	50° 12′	∠L
	18	A	54° 22′	∠L

117.118
Figure 8-12.—Pile location sheets.

after the pile has been driven to the specified penetration. Precast concrete piles are much harder to cut than timber piles, and an attempt is therefore made to drive the butts of concrete piles to exact elevation. This is not always possible, however, and concrete piles must frequently be cut to correct elevation like timber piles. Concrete piles may be cut with pneumatic chisels (for cutting the concrete) and oxyacetylene torches (for cutting the reinforcing steel). Timber piles are cut with a chain saw or a one-man or two-man crosscut saw.

Since the pile cap must bear evenly on all the piles in the bent, it is extremely important that they all be cut to exactly the same elevation. This is ensured by the use of a CUTTING GUIDE or SAWING GUIDE like the one shown in figure 8-13(B). The position of the cutting guide is determined by locating the correct elevation of the bottom of the cap on the two outside piles in the bent, usually by means of a builder's level set up on the shore or on a bent previously constructed.



117.119
Figure 8-13.—Constructing a pile bent.

Capping Piles in a Bent

After timber piles in a bent have been straightened, aligned, and cut, the piles are usually capped. The cap is set in place, a hole for a drift bolt is bored through the cap into the top of each pile, and the drift bolts are driven (see fig. 8-13(C)). The transverse and longitudinal bracing is then put on. Sometimes, however, the bracing is installed before the caps.

After concrete piles have been straightened, aligned, and cut, the caps are usually cast in forms built across the tops of the piles. Figure 8-14 shows concrete piles before and after cutting.

The falsework serves as a guide for cutting, as a working platform, and as a support for cap, girder, and slab formwork. For an all-concrete structure the caps, girders, and deck slabs are usually all cast at once, in forms like those shown in figure 8-15.

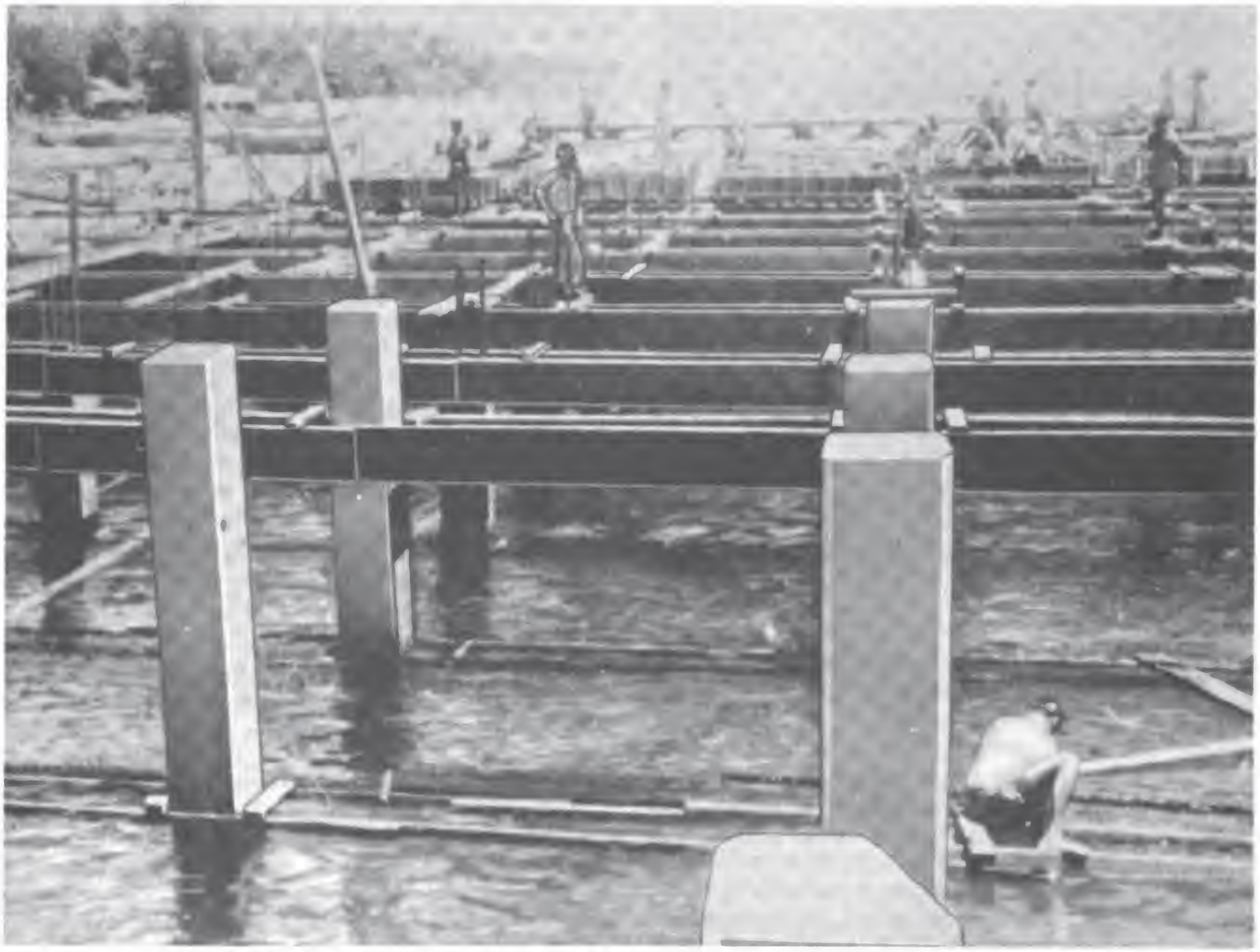
CONSTRUCTION METHODS FOR PILE BENT STRUCTURES

If the pile driver is a floating rig, it may be used to drive the piles for the whole structure in advance of the rest of the work. When the piles in one bent have been driven, the rig is floated on to the location of the next bent, without waiting for the piles just driven to be capped and braced.

Driving From the Deck

In the absence of a floating rig, the pile driver is usually operated from the deck of the structure. There are two general procedures commonly followed for moving the rig forward. In the so-called WALKING STRINGER method, the piles in each bent are straightened, aligned, cut, capped, and braced immediately after they are driven. Movable temporary stringers are then laid ahead of the pile driver, and the driver advances over them to drive the next bent. The pile whip on the pile driver is used to swing the temporary stringers from behind to ahead, and the permanent superstructure (stringers and decking) can be constructed later as convenient.

In the so-called FINISH AS YOU GO method the permanent superstructure is load ahead of the pile driver, and the driver advances over the permanent decking. In this method, of course, the pile driver cannot advance to the next bent until the intervening permanent superstructure has been erected.



133.226
Figure 8-14.—Concrete piles before and after cutting, showing falsework.

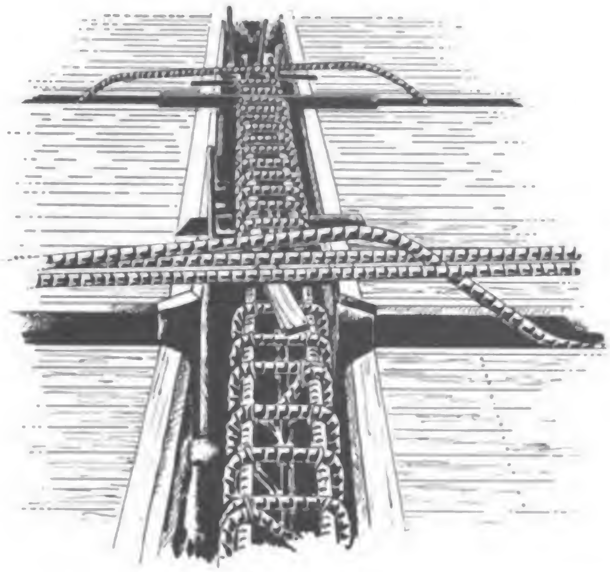
Driving From Temporary Causeway

In relatively shallow water the pile driver may advance over a temporary earth causeway built out from the shore. The piles are driven down through the causeway fill into the permanent bottom. As the pile driver advances, the causeway is built up ahead by excavating and carrying forward material from behind.

COFFERDAMS

When a shaft for a foundation, or for some other construction purpose, must be excavated to a considerable depth, provision must be made for excluding soil and/or water from the excavation. The most common method of doing this involves (1) the insertion of vertical sheathing around the limits of the excavation, (2) the excavation of material inside the sheathing, and (3) bracing the sheathing as excavation proceeds. A structure of this type is called a COFFERDAM.

A typical application of cofferdams is in the construction of bridge piers in a stream. Construction of a concrete bridge pier usually begins with the driving of a steel sheet pile enclosure at the pier location. This is usually braced with prefabricated structural steel wales which fit inside the enclosure and are bolted to the piles. After the pile enclosure is driven and braced, the river water inside the enclosure



133.227
Figure 8-15.— Formwork for concrete pile caps, girders, and deck slab.

is pumped out, and excavation of the bottom can then be done. For a large bridge, excavation is usually carried down to bed rock. If the first piles driven are not long enough to reach bedrock, additional stages are driven as necessary. For excavations which go down far enough to create pressure problems, caissons are used instead of cofferdams.

Sheathing for a timber cofferdam may consist of ordinary square-edged timbers; however, when much water must be excluded it is usually necessary to use wood sheet piling. Timber sheathing for a cofferdam is called LAGGING.

MAINTENANCE AND REPAIR OF BRIDGES, TOWERS, AND WATERFRONT STRUCTURES

The maintenance of various structures should be designed to include (1) the prompt detection of deficiencies or damages, and (2) the expeditious performance of repairs, consistent with requirements, in an economical and workmanlike manner. These requirements are essential if the maintenance standards are to be achieved.

Detection is provided by inspection of facilities at regular scheduled frequencies by qualified inspectors. The inspection program should also include emergency inspections prior to and following unusual and severe storms where high velocity winds, abnormal tides, and heavy wave action have been experienced; when heavy snowstorms and extremely low temperatures are anticipated or experienced; and after the occurrence of any operational hazards. Routine maintenance and repair work should be taken care of promptly after deficiencies are noted by the inspector, with priorities being established for the required work.

Maintenance and repair procedures involving various types of materials (concrete, metal, etc.) used in different kinds of structures found at Navy activities are described in the following sections.

CONCRETE

Good Portland cement concrete is a fairly permanent construction material, but local conditions can produce defects that require corrective measures. The BU should be familiar with common types of defects that occur in concrete and know what measures to take to correct these defects.

Repairing Concrete

When concrete that covers reinforcing steel is deteriorated, spalled, or cracked, the reinforcing steel begins to rust and repairs should be made promptly to avoid excessive damage. All loosened materials must be removed and the concrete cut back to sound material. Cut the areas to be patched a minimum of one inch and at right angles to the surface. If the reinforcing steel is seriously damaged by rust, cut the concrete back far enough to replace the damaged steel by new reinforcing. New reinforcing bars should match the original bars in size and grade of steel and should be lapped at each end for a length of not less than 30 diameters of the original bars or as directed by higher authority. The new bars must be securely wired or welded to the old before patching. Exposed reinforcing steel that is not seriously damaged by rust should be cleaned by brushing or sandblasting so as to make a firm bond with the new concrete. Reinforcing steel should be covered by a minimum of three inches of concrete if at all possible.

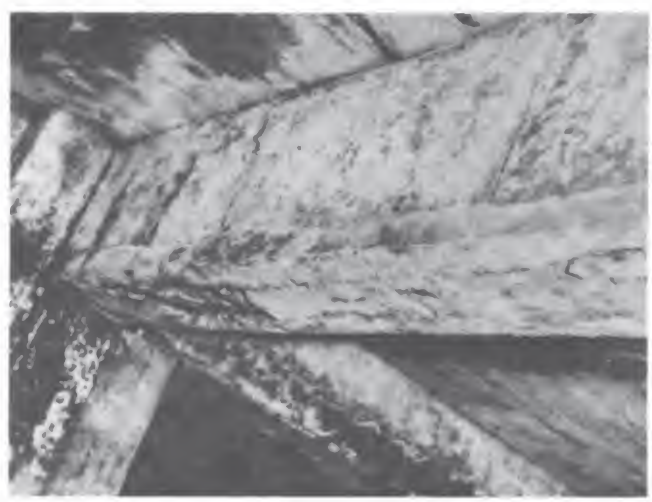
Superstructure Repairs

Repairs to superstructures will include filling surface cracks, replacing structural members, cutting and filling expansion joints, and resurfacing decks.

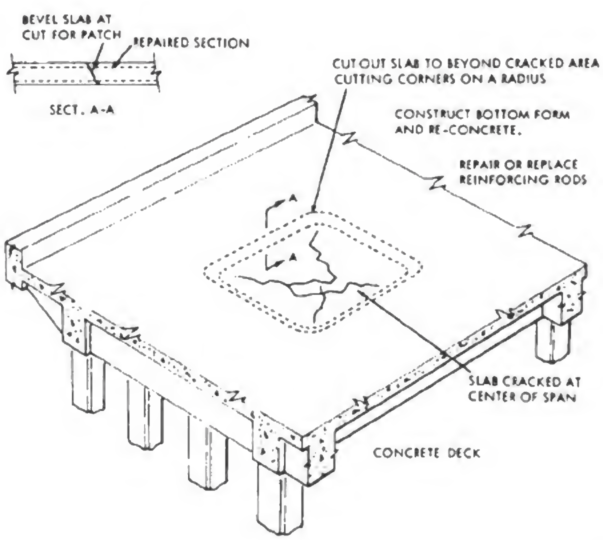
SURFACE CRACKS. — Surface cracks that are not structural defects must be promptly filled to avoid the entrance of water. Thoroughly clean the crack with a high-pressure water jet to remove all foreign matter. Edges of the crack should be moistened but not wet. Fill the crack with a thin grout of cement and water, using a brush if necessary to push the grout in the crack. For wider cracks, use a mortar of cement, sand, and water instead of cement grout. If such cracks are of insufficient width to permit placement of filler material, they should be cut out prior to cleaning. After filling the crack, cover with burlap or sand and keep the covering moist for at least three days. Asphalt, tar, and certain other materials may also be used with satisfactory results for sealing random cracks in concrete decks and curbs.

117.268
Figure 8-16. — Repair of spalling.

PATCHING AND REPLACEMENT. — Forms are usually required except for minor patches on top of a slab and for pressure-applied concrete. Forms may be of pipe, sheet metal, or wood and either left in place or stripped. They should be strong, well-braced and, if to be stripped, designed so they can be removed without damaging the concrete. Pressure-applied concrete is generally used to repair spalling on the underside of a deck or beam. (See fig. 8-16 and 8-18.) Cut back the spalled area to sound concrete, and repair or replace reinforcement as described earlier. Then rebuild to original section with pressure-applied concrete. Slabs or other structural members that are broken or severely damaged must be replaced. The assistance of qualified engineers should be obtained to analyze such cases, to determine the cause of failure, and to furnish an adequate design of replacement members. Methods of patching deck slabs of reinforced concrete piers are shown in figures 8-18 and 8-19. Slabs may be broken through by overloading. If this is a relatively small area and near the center of a span, it can be repaired by cutting out the deck and reconcreting, as shown in figure 8-17. To repair a hole, concrete may be beveled, as shown in figure 8-18; or, in addition to beveling, the area to be removed may first be scored along the breakline, using a saw, to a depth of 1-1/2 inches. The depth is to be adjusted where reinforcing is encountered. No joint in the slab should be made adjacent to, or at the edge of a supporting beam nor at or near the ends of reinforcing bars. If it is necessary to cut the slab back to the supporting beams, or replace the slab, a seat should be cut into

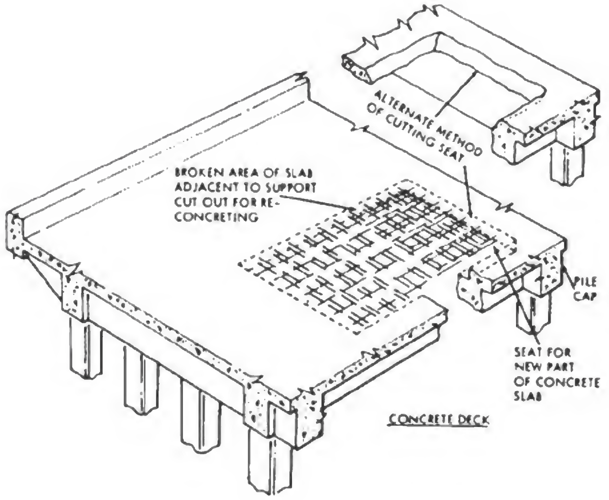


117.269
Figure 8-17. — Cracked and spalled beams.

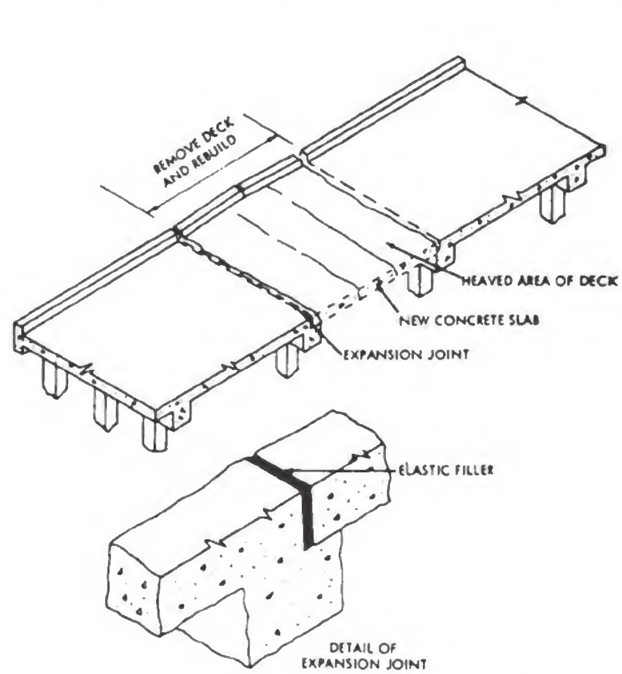


117.270
Figure 8-18.— Repair of deck at center of span.

the beam to the depth of the slab and one-quarter to one-third the width of the beam. (See fig. 8-19.) If deck slabs have been damaged by heaving, they must be replaced. Make provision for adequate expansion joint in the new slab. (See fig. 8-20.) If two or more adjacent slabs have heaved, it will often be found that piles have been pulled



117.271
Figure 8-19. — Repair to damaged edge of slab.

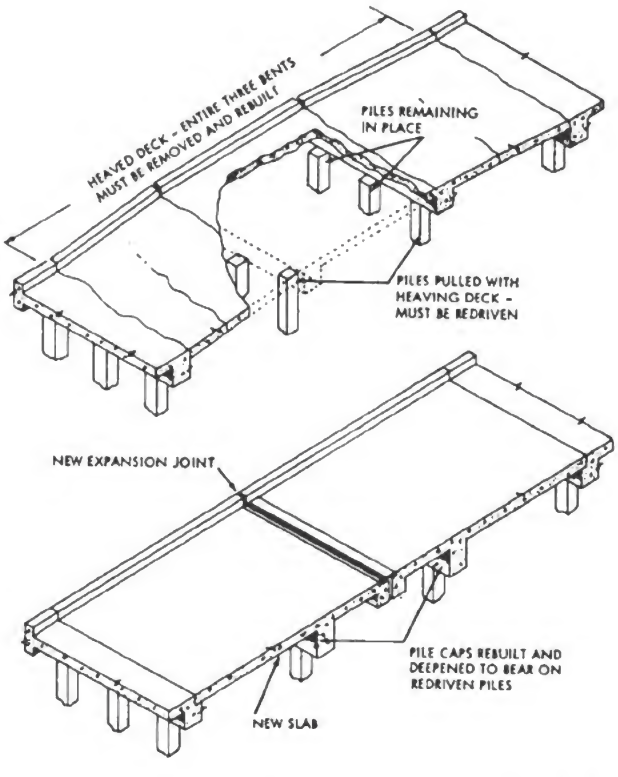


117.272
Figure 8-20.— Heaving of concrete deck.

up with the slabs. When this condition occurs, the piles should be redriven to a firm bearing and necessary repairs made to concrete caps. (See fig. 8-21.)

EXPANSION JOINTS.—Where expansion joints have proven inadequate in number or are not functioning properly, heaving will result. Where joints are too far apart, cut additional joints with a concrete saw and fill with an approved type joint sealer. Asphalt, tar, and certain other materials may be used with satisfactory results for sealing joints. Sealing material should adhere to the concrete and should remain plastic at all temperatures. It should not become hard and brittle in low temperatures or become so soft that it flows from the joint during intense heat or so tacky that it is picked up by vehicle tires.

RESURFACING. — Portland cement concrete pier decks that have widespread surface deterioration may be restored by resurfacing with asphalt. The existing slab must be properly prepared prior to placement of new asphalt surface course. Clean all loose, scaled, and foreign matter down to sound concrete, using power wire brooms and compressed air. Flush with high-pressure fresh water to remove salt, if near sea water. All cracks must be cut to a clean rectangular trench, usually not less than 1/2-inch wide by 1-1/2-

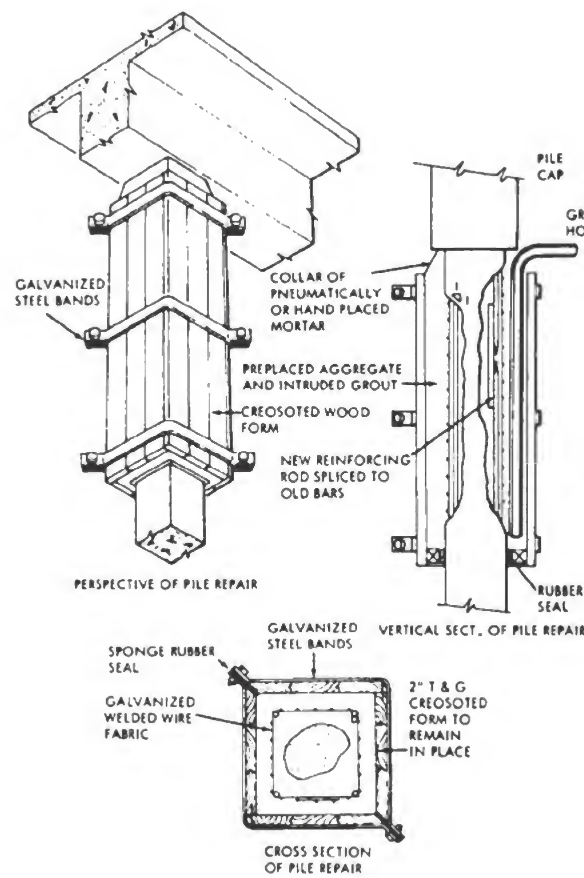


117.273
Figure 8-21.— Piles pulled by heaving deck.

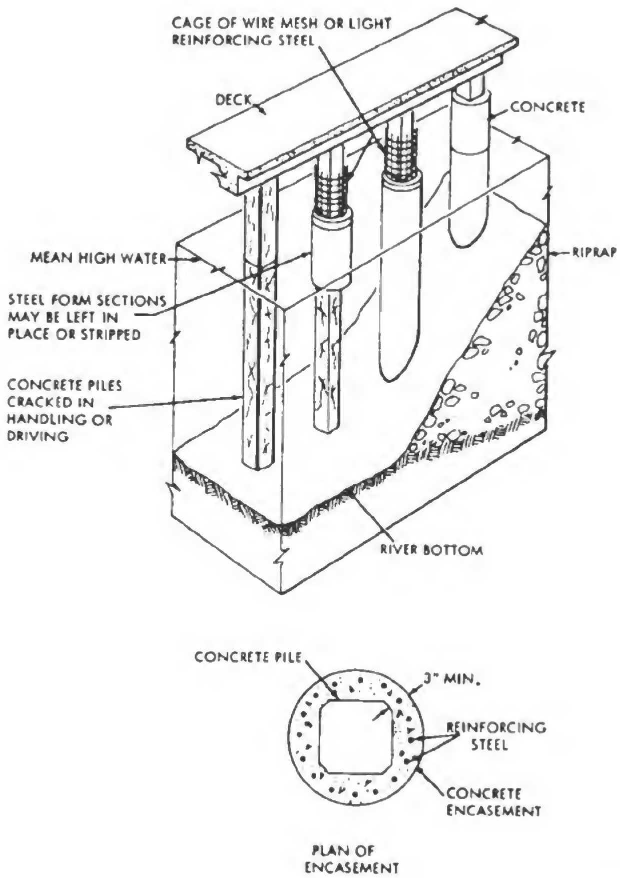
inches deep (adjust depth to suit reinforcing steel). Fill trench to with 1/2 inch of the top with a high softening point asphalt mastic or joint-filling compound. Paint the surface of the concrete for three to four inches on both sides of the trench with asphalt emulsion and cover with 30-pound asphalt-impregnated felt 4 inches wider than the trench. It is very important to seal the cracks properly to eliminate reflection cracking and subsequent premature failure of the new asphalt surface cover. Liquid asphalt is applied to the surface of the Portland cement surface as a primer, and a dense graded mix of asphalt concrete or sheet asphalt is laid as a surface in accordance with a predetermined design. To protect concrete from chemical deterioration, a practical remedy is to apply a layer of dense impervious concrete properly anchored to the old work or some of the newer materials, such as epoxy resin formulations.

Substructure Repair

Free standing components of structures damaged or deteriorated by such means as spalling or longitudinal or horizontal cracks in piles and bracing can be repaired above the waterline. Pressure-applied mortar, epoxy formulations, normal Portland cement concrete, or grout are applicable materials. Encasement of damaged portions in reinforced concrete is the conventional method of repairing piling. It is always preferable to place concrete in air if economical and feasible; however, this requires the use of cofferdams, and it is not always an economical solution. When the solution dictates, concrete can be placed under water. Forms may be used as shown in figures 8-22 and 8-23. Additional reinforcing in the form of rods or mesh is placed around the damaged pile, and sectional forms are used to hold the concrete in place until it cures. Forms may be made of pipe, sheet metal, or wood and are split in half vertically so that they can be placed around



117.274
Figure 8-22.— Encasement of damaged piles (wood form).



117.275
Figure 8-23.—Encasement of damaged piles (metal form).

the pile and bolted together above the water. Each section is then slid into place and new sections added until the desired length is obtained. The form is then filled with concrete. Forms may be left in place or removed for reuse. Where only a section of the pile is to be encased in concrete and the forms do not extend to the mud line, the lowest section of the forms must be closed to hold the concrete or aggregate and grout in place. (See fig. 8-23.) Pressure-applied concrete may be used to make sectional forms. These are built upon cylinders of expanded metal laths shaped to fit around the pile. Wire mesh reinforcement may be used outside of the metal lath where additional strength is required. Pressure-applied concrete is used to make a sectional form one or two inches thick, and the concrete is allowed to set. This form is then dropped into place and filled with concrete.

METAL

Inspections of corroded, weakened, or damaged areas are essential for determining the best methods or needs for repair coating or replacement of steel members in the various structures. Main members are normally replaced when 30 percent or more of the section has been removed by corrosion or when seriously deformed. In the planning of replacements, consideration must be given to the rate of corrosion or actual decrease in section. If adjacent members show signs of serious deterioration, it may be best to replace whole frames or bents. Never remove a stressed member until the stress has been relieved by temporary bracing, shoring, or jacking, because, if the stress is not removed, the member may spring out of place when loosened, making it very difficult to replace the member. In the replacement of piles, the load should be shifted temporarily to adjacent piles by means of temporary beams or jacks. The replacement of wales on bulkheads may require the excavation of the fill to relieve the lateral loads. The structures must retain their structural stability at all times. In most cases the maintenance and repair of metal structures will be handled by the Steelworkers. At times, though, the Builder may be working with the Steelworker in these operations, so let us consider some of the common methods of maintenance and repair.

Maintenance Methods

New members must be accurately fabricated to match the old work. Special care must be taken to be sure that all bolt and rivet holes line up with original members. Prior to the placement of the new member, all old rivets or bolts must be removed in the most expeditious manner by using hand or pneumatic chisels, saws, wrenches, or by burning them off before removing the old member. Place the new member in position and line up all holes by adjusting jacks or bracing as necessary. Place a few bolts to hold the member, then fasten securely in place by riveting, placing additional bolts, or welding.

In the replacement of bearing piles, the new pile is generally driven alongside the old one at a slight angle. It is then cut off at the proper elevation, capped, usually by welding on a steel

plate, and pulled into position by block and tackle. If the old pile is pulled and a new one driven, care must be taken to transfer the load temporarily until the new pile can assume the load. Care must be taken to bore or punch the bolt holes in the cap to conform with the holes in the floor beam or stringer.

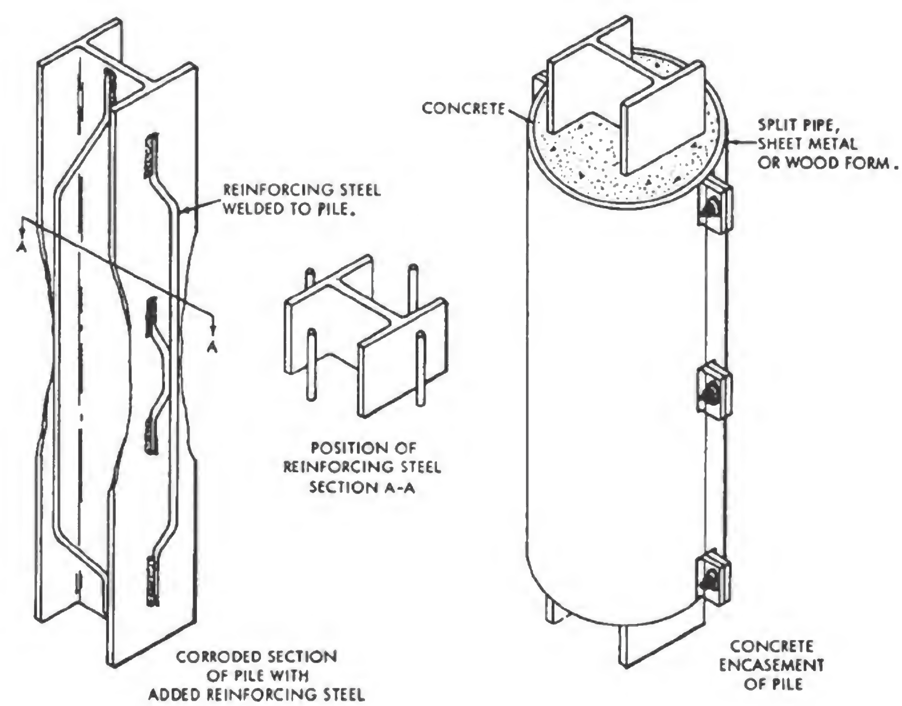
Precautions may be necessary when replacing wales and sheet metal bulkheads because they often retain materials that have a low angle of repose. The old wales are left in place or at least until new wales are installed just above or below the originals. Occasionally they can be connected to existing tie rods; however, in most cases, new tie rods and deadmen should be installed.

Badly deteriorated sheet pile is generally protected by new sheet piling being driven outside the old piling and provided with new wales, rods, and deadmen. The space between the piles must be filled with well-tamped earth, sand, gravel, or concrete, depending upon conditions at the site.

Steel members that have corroded in only limited areas may be repaired by welding fish plates onto the flanges and web. The corroded area should be first thoroughly cleaned and feather edges burned off back to a point where the metal is of sufficient thickness to hold a weld. Fish plates should be of sufficient cross sectional area to develop the full strength of the original section and should extend beyond the top and bottom of the corroded zone. Another method is to encase the corroded section in reinforced concrete. After cleaning the corroded area and cutting back the corroded edges, weld the reinforcing rods to the flanges and web. A form is then placed around the corroded section and filled with concrete. Figure 8-24 illustrates this procedure for steel H-pile. The same system can be used for other structural members.

Sheet Piling Repair

Sheet piling usually serves as a bulkhead to retain earth or other fill. Holes in the bulkhead will result in loss of materials and settlement behind the bulkhead. Local damage or holes can be repaired by welding on plates, or sections of steel sheet piling. If the holes are small, wooden plugs can be used to fill the holes.



117.276
Figure 8-24. — Concrete encasement of steel pile.

Usually it is necessary to install new sheet piling in the deteriorated areas; however, it may be economically feasible to protect the damaged sheet piling with a concrete facing, as shown in figure 8-25. Remove all rust, scale, and marine growth before placing concrete. Concrete cover, when applied to the exposed exterior face of the piling, should be at least 6 inches in thickness and extend well beyond the area of corrosion, damage, or deterioration. Form work should be of wood, supported in place by stud bolts that are welded to the sheet piling. Use heavy zinc-coated bolts and nuts. It is preferable that the wood forms be left in place, because they will provide protection against damage from floating debris and erosion for some time. Where the back of the bulkhead can be easily exposed, it may be advisable to completely encase the sheet piling in concrete. Minimum thickness of concrete facing where the piling is completely encased in concrete should be 3 inches. Care must be taken in replacing backfill when sheet pile has been encased. GRANDULAR materials are preferable. Fill should be placed in layers and well compacted.

Tie Rod Repair

Deteriorated tie rods will allow the top of a bulkhead to move outward. Remove the fill to expose the tie rods and turnbuckles by starting the excavation at the back face of the bulkhead and progress inshore in as narrow a trench

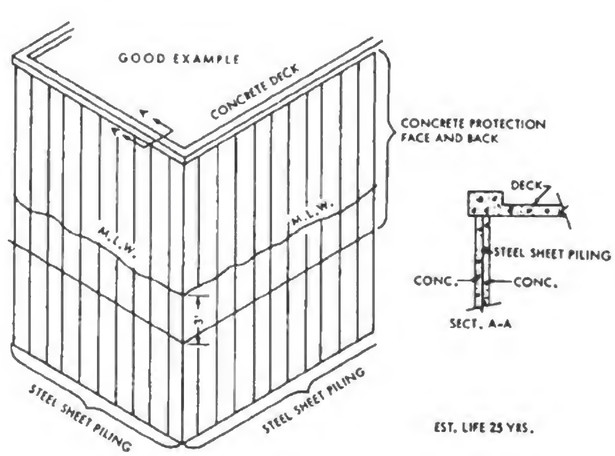


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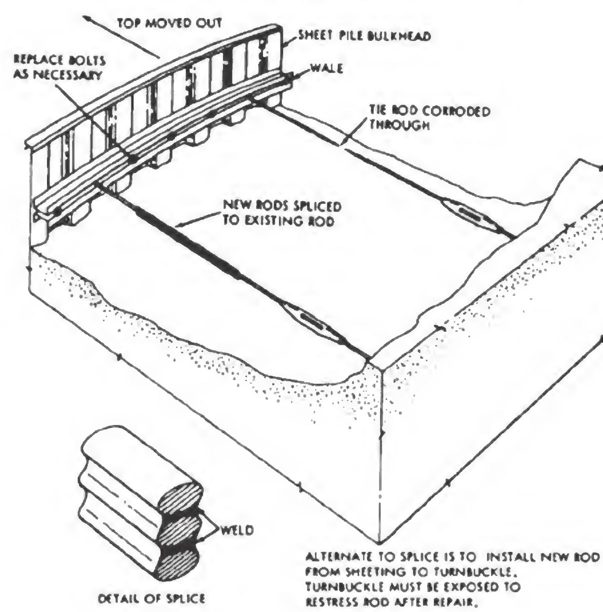
Figure 8-25.—Concrete encasement of steel sheet pile.



117.278

Figure 8-26.—Repair of tie rods.

as practical, along the tie rod to the deadmen. Thoroughly clean the tie rods and turnbuckle by removing rust and corrosion. Repairs may be made by welding new rods onto the corroded area (see fig. 8-26) or by installing new rods from the turnbuckle to the face of the wall or outside of the wales. Check the condition of the deadmen and either make necessary repairs or strengthen them, as required. Tie rods should be replaced or repaired, one at a time. Coat new work with bituminous material, wrap with fabric tape, and apply another coating of bituminous material over the tape; and then backfill the trench.

WOOD

Wood pile and timber structures in a marine environment are susceptible to infestation and attack by marine organisms or wood rot spores. Therefore, treated piles and timbers should be used in the repair or replacement of such members in structures unless there is a specific reason for doing otherwise, on the basis of the economic expected life. Southern Yellow Pine, Douglas Fir, and oak have been found to be most suitable for waterfront structures; however, hemlock, larch, spruce, cedar, and tamarack can be used. Figure 8-27 shows an untreated timber destroyed by marine borers in

117.279
Figure 8-27. — Pile cap destroyed by marine borers.

seven months. Bolts, washers, spikes, drift pins, and other hardware used in repair of timber members must be heavily galvanized.

Decking

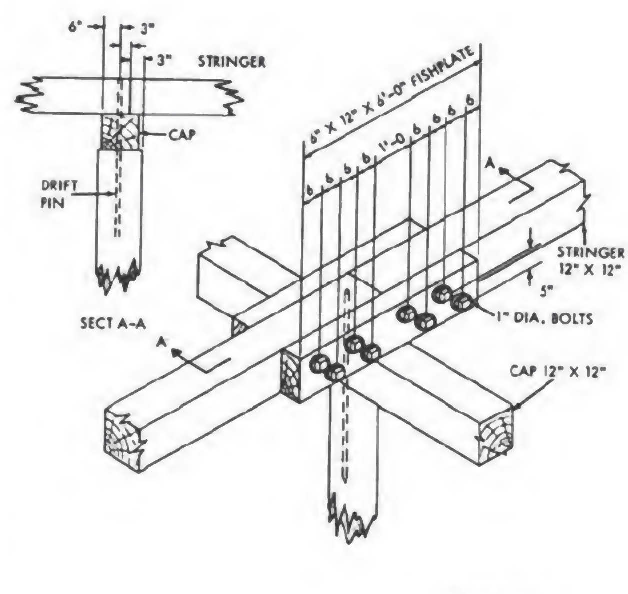
The use of creosote-treated lumber for wood "decking" is not recommended. Deck surfaces drain rapidly and, being well ventilated, dry rapidly so that the principal concern is not the same as it is for the covered, unaccessible structural framing. Usage and wear from traffic is generally the cause of deck repair and replacement. Top surface decking, over which vehicular and pedestrian traffic passes, should be replaced when the top surface becomes excessively uneven, hazardous, or worn to a point of possible failure of the decking. Replacement should be with edge-grain timber, surfaced on four sides. Decking should be laid with 1/2-inch to 3/8-inch space between each plank to permit ventilation and drainage. The top surface should be reasonably smooth and level, particularly where repaired areas meet existing decking. End joints should be staggered where existing and new decking meet. Decking should be nailed securely at every stringer with 6-inch spikes for 3-inch decking and 7- or 8-inch spikes for 4-inch decking. Spikes should be driven flush with the top deck planking. Care should be taken to rebuild into the repaired decking area openings or access for under-pier fire-fighting nozzles or sprayers and for access to piping, valves, and fittings. Decking for relieving platforms that have an earth-fill should be a double layer of pressure-treated lumber laid without spacing between planks.

Stringers

Stringers that have rotted or have been damaged should be replaced. Replacement stringers should be tightly bolted where they lap with existing stringers that are to remain, and they should be pinned or bolted down to caps. Stringers that extend continuously for the length of the pier may be replaced in part by splicing to sound parts of the timber. Splices should be placed directly over pile caps, and the splices in adjacent stringers should be staggered where possible. A typical splice for a 12-inch by 12-inch stringer or cap is shown in figure 8-28.

Pile Caps

Pile caps that require replacement because of rot or damage should be completely replaced between the splices of the original structure. Bolt holes in new caps should be carefully made



117.280
Figure 8-28. — Stringer splice.

to align properly with bolt holes in existing caps. It is preferable to use new fish plates, particularly if they are of timber. A typical splice is shown in figure 8-28.

Braces

Diagonal and sash braces that have rotted, have been broken, or have been weakened by marine borer attack should be replaced. Each brace should be replaced completely rather than spliced. Bolt holes should be carefully placed for proper alignment. When wood braces are fastened to piling, the pile should not be cut to obtain a flush fit. The braces should be bolted, if possible, above the high waterline. After drilling, bolt holes should be treated with preservative, preferably with a specially designed bolt hole treater that forces the preservative into the hole under pressure. Where decking has been removed for repairs, it is often possible to drive brace piles to provide lateral stiffness. This eliminates all bolt holes except at the top of the structure immediately under the decking.

Fire Curtain Walls

Fire curtain walls that have rotted or that have been damaged or severely attacked by marine borers should be restored to the original condition. When damaged timbers are replaced they may be spliced out. Splices should not be made in the same location on both sides of the wall because an open crack would remain. The curtain wall should be as airtight as possible after repairs are completed. Wood fire curtains are usually made of two layers of timber, the joints in one layer running diagonally to the joints in the other. It is important that the joints be tight and that both sides of the wall be completely repaired.

String Pieces

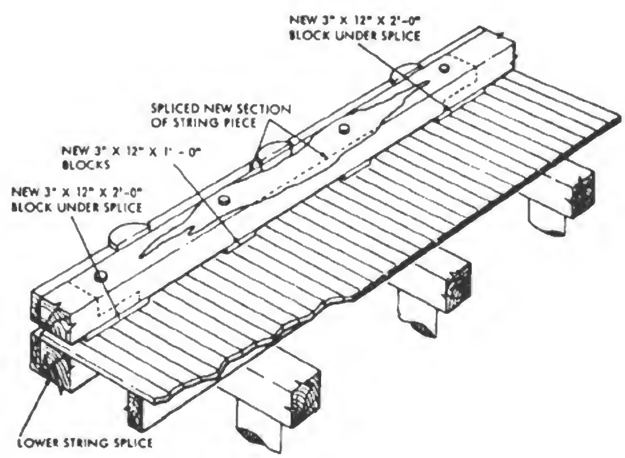
The string piece is sometimes referred to as the curb, bullrail, or backing log. Because of its exposed position, it is subject to much wear and, in addition, to constant wetting and drying. It is bolted to the caps and lower string piece. The string piece may be repaired by splicing in new material as needed. The length of the replaced sections should be not less than two complete bents. The string piece should be set on blocks between two and three inches thick and between three and four feet on centers to permit drainage under the string piece. New blocks should be placed under any part of the string piece that is replaced. If it is necessary to replace any part of the lower string piece, it should be replaced for the full length of the timber as originally built. (See fig. 8-29.)

Chocks

Chocks between piles that are rotted or broken, as shown in figure 8-30, should be replaced. The new timber chock should be tightly fitted in place and bolted to one string piece. (See fig. 8-31.)

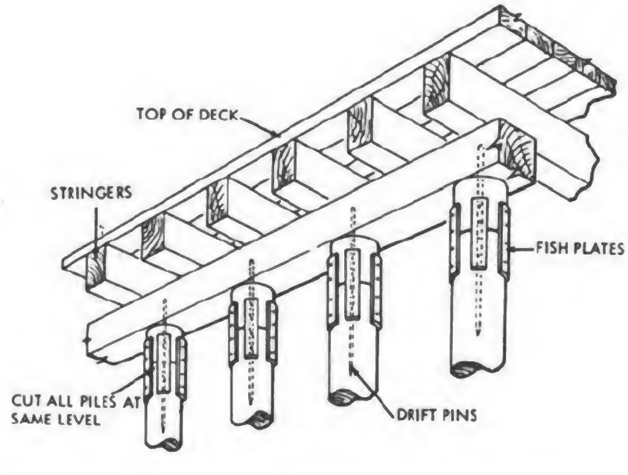
Wood Piles

The decayed top of woodbearing piles can be repaired by cutting off the damaged portion and building up to the proper height with sound timber. (See fig. 8-32.) Drift pins should be driven through the cap and down through the new section of pile. This involves the removal of some of the deck planking. In every case, fish plates of metal or treated wood should be used to hold the new section in place. Fasten fish plates securely with spikes, lag screws, or bolts. Where all the piles in a bent have decayed tops, but there is less than a foot of unsound piling, the method shown in figure 8-33 may be used. The top of each pile in the bent is cut off to allow the installation of an additional 12-inch x 12-inch cap under the existing cap. Drive drift pins through caps into the piles to hold the tops in place. In most cases,



117.281
Figure 8-29.—Repair of string piece.

117.282
Figure 8-30. — Decayed chock.

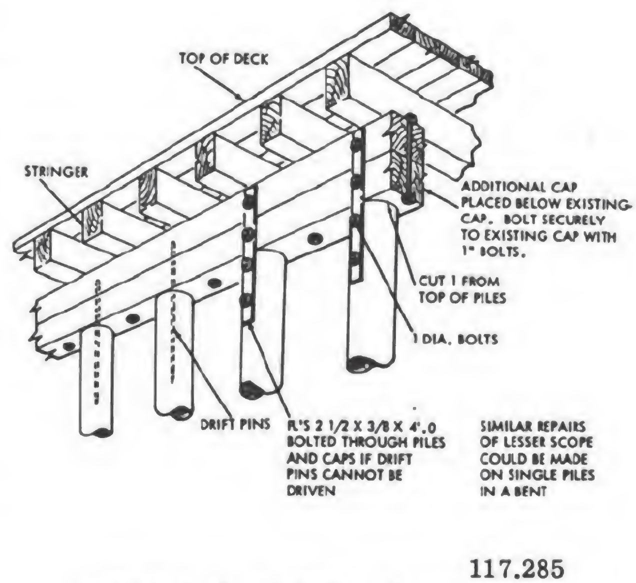


117.284
Figure 8-32.—Replacing tops of piles.

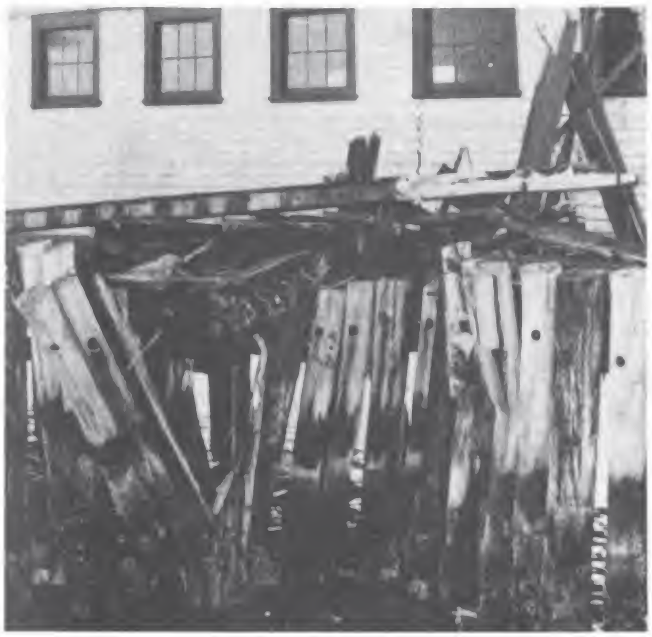
the connection of caps to piles should be further strengthened by bolting them together with 1-inch bolts and 2-1/2-inch x 3/8-inch steel straps. Use 1-inch bolts for bolting the two caps together.

Piles that are broken or badly damaged should be replaced. (See fig. 8-34.) The old pile should be pulled and a new one driven in its place. Where old piles cannot be pulled or where they break off, the old pile must be cut off as far down as possible and a new pile driven alongside of it. After driving, the head of the new pile is pulled into place and fastened to the cap with a drift pin, or by the use of fish plates. (See fig. 8-35.) Treated replacement piles should be used for all structural pier piles; however, on

117.283
Figure 8-31. — Chocks between fender piles.



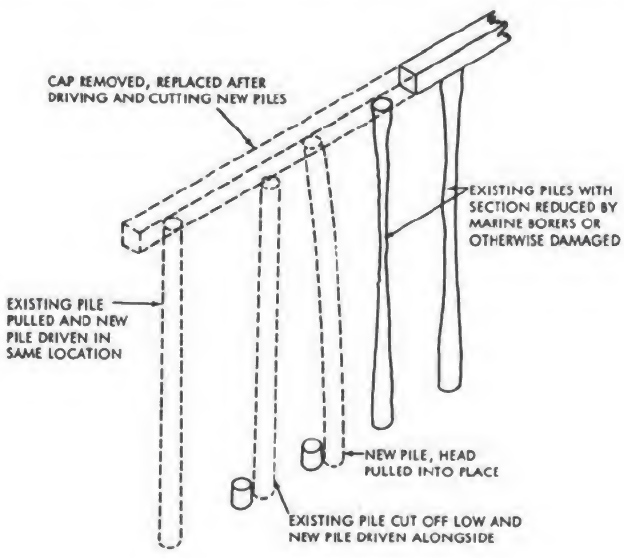
117.285
Figure 8-33. — Repair of top of piles.



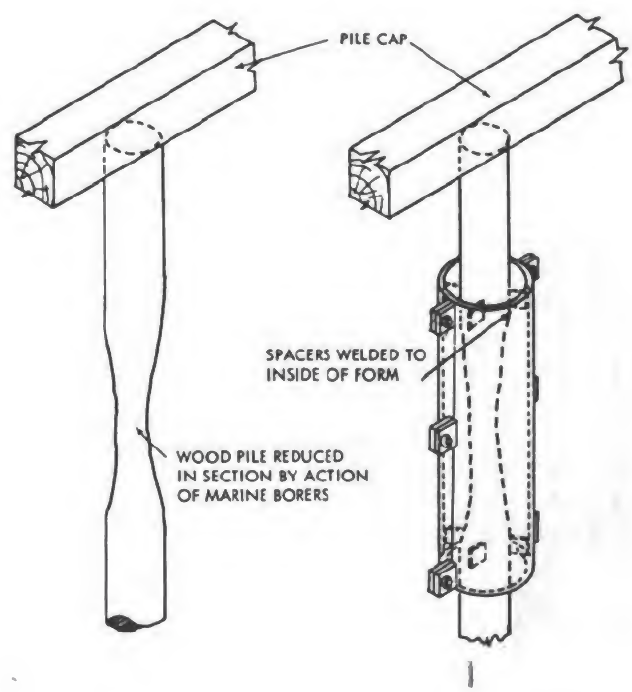
117.286
Figure 8-34.—Broken wooden piles.

major operations and supply piers, where the life expectancy of the fender system is relatively short because of its continuous exposure to the berthing of major ships, the use of untreated, unskinned piles may be considered structurally suitable and economically sound.

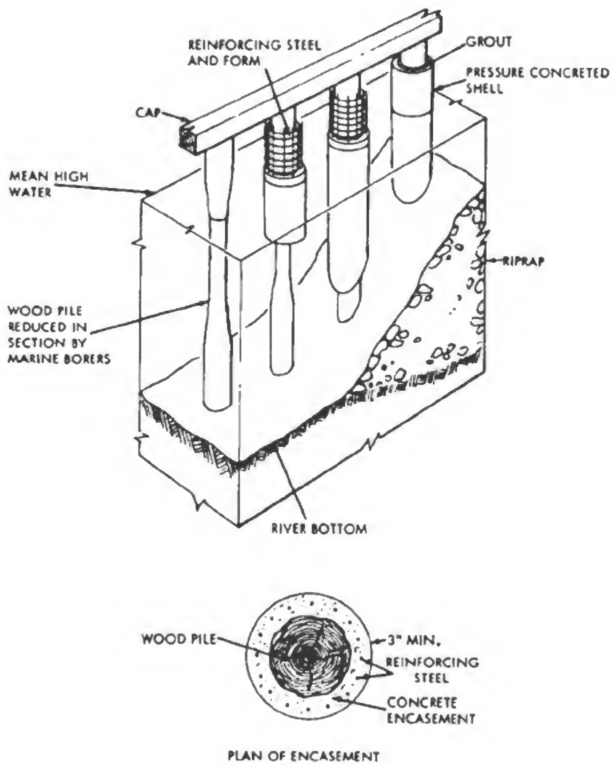
Piles that have been weakened by marine borers can be strengthened and protected by encasing them in concrete jackets. Steel reinforcing can be used in the concrete jacket, either in the form of bars or wire mesh. Concrete encasement may be used to cover a short section of the pile, where damage is limited, as shown in figure 8-36, or may be extended well below the waterline as shown in figure 8-37. The damaged surface of the pile must be scraped to sound wood. Either metal or wood forms may be used. If wood forms are used, a 2-inch creosoted tongue and groove material should be used and left in place. Fender piles that are broken between the top and bottom wales, as illustrated in figure 8-38, can be repaired by cutting off the pile just below the break, then installing a new section of pile and fitting. Place and bolt a pile section or timber section directly behind the fender pile from top to bottom wales. A metal wearing strip should be spiked to the wearing edge of the pile.



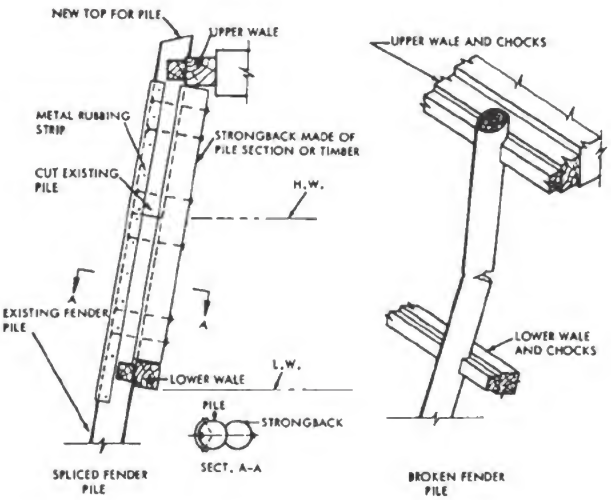
117.287
Figure 8-35.—Wood pile replacement.



117.288
Figure 8-36.—Concrete encasement of short section of wood pile.



117.289
Figure 8-37. — Extensive concrete encasement of wood pile.



117.290
Figure 8-38. — Fender pile repair.

Sheeting

Piers and quay walls may have a bulkhead of wood sheet pile to retain the fill on the shore side. Riprap is usually placed at the foot of the sheeting for strengthening. Extensive deterioration of the bulkhead will result in loss of fill and settlement above the affected area. Repairs usually require the driving of sheet piling to form a new bulkhead a minimum of one foot inside the old one, so as to avoid the driving frames or wales attached to the old bulkhead. New sheet piling may be pressure-treated wood, concrete, or sheet steel. Steel sheet piling may be pressure-treated wood, concrete, or sheet steel. Steel sheet piling is normally used for the new bulkhead, because oftentimes the work must be done inside a pier shed. In this case, steel piling is driven in maximum lengths possible and additional lengths welded on successively. The new sheet pile should extend to a minimum of three feet below the toe of the deteriorated wood sheeting. The fill at the inside edge of the old bulkhead is normally removed before driving the new sheet piling. When this is done, a concrete cap should be placed over the new sheeting to form a seal with the existing construction.

Dolphins

Maintenance of dolphins includes the replacement of fastenings and any wire rope wrapping that has become ineffective through corrosion or wear. If dolphins are connected by a catwalk, maintenance of the catwalk includes the replacement of damaged or deteriorated timbers or the cleaning and painting, or the replacement, of the steel members. Repairs of dolphins include replacement of piles, wire rope wrappings, and blocking. If any piles have to be replaced, the fastenings should be removed only as far as necessary to release the piles that are damaged. Care should be taken to drive the new piles at the proper angle so they will not have to be "pulled" too far to fit them in place. The size of piles to be replaced should be carefully noted, particularly at the head or intermediate point where they are fitted together with the other piles. Much trouble in cutting and fitting the replacement piles can be avoided by selecting piles with the proper size head. All replacement piles should be driven before any are brought together. After all are

driven, the center cluster should be brought together first, and should be fitted, chocked, bolted, and pinned; they are then wrapped with wire rope. All cuts in piles for fittings, bolts, and wrappings should be thoroughly field-treated with creosote. Frequently, it is more economical to build a new dolphin rather than to repair an existing one.

STONE, MASONRY, AND EARTH

Some structures, such as breakwaters and seawalls, depend upon their mass for stability against wave action and currents. Materials commonly used for such structures are stone, blocks of concrete, cast-in-place concrete, and earth. Earth structures are usually covered with a protective coating, such as riprap, to hold them in place.

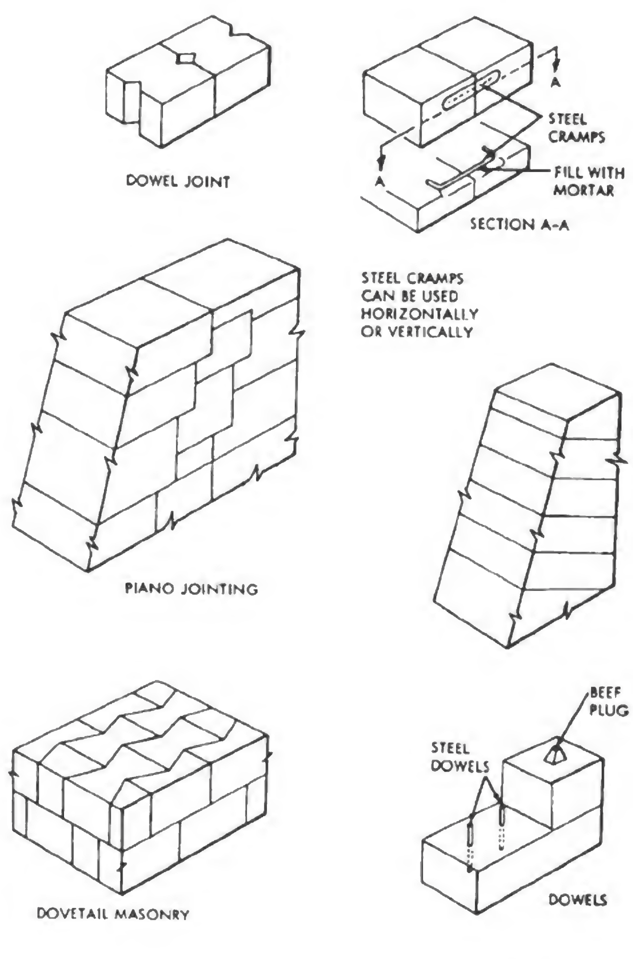
The most common cause of deterioration and damage to mass structures is wave action, particularly during storm conditions. Severe wave action may move stones out of place, when built into a wall, or move others by washing out sections of a breakwater or causeway. This damage makes the structure more susceptible to additional damage. Repairs should be made as soon as possible.

Stone Structures

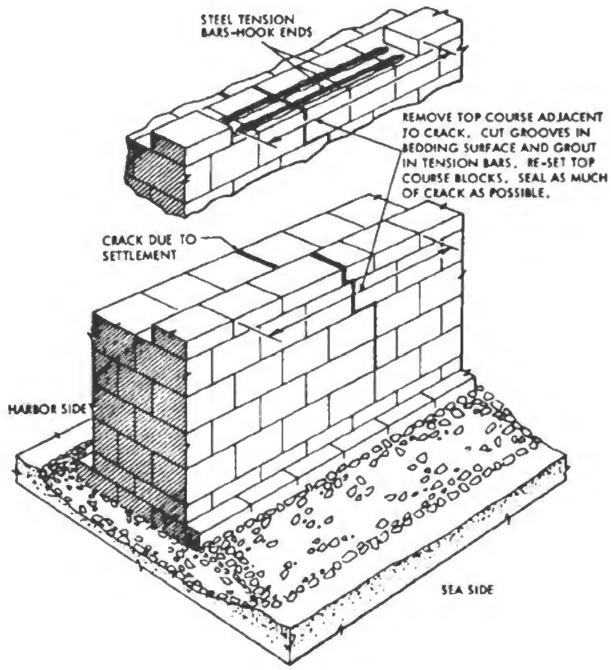
Stone structures are considered to be those constructed of stone, blocks of concrete, or special concrete shapes, such as tetrahedrons, piled up or distributed in a random fashion. Some structures may have an earth core retained in place by stone composing the area that is exposed to wave action. In repair of the damage, consideration must be given to the cause of damage, such as, an unusually severe storm, need for strengthening of structure, and too steep side slopes. Unless it is evident, after study by design engineers, that changes in design are required, the structural damage should be repaired with materials the same as the original to restore the structure to its original strength, elevation, and cross-section. Depressions washed out of the bottom in the vicinity of structures should be replaced with sand or GRANDULAR materials up to original level before replacing stone, either by dumping from the undamaged part of the structure, or by placing from a barge using a floating derrick.

Masonry Structures

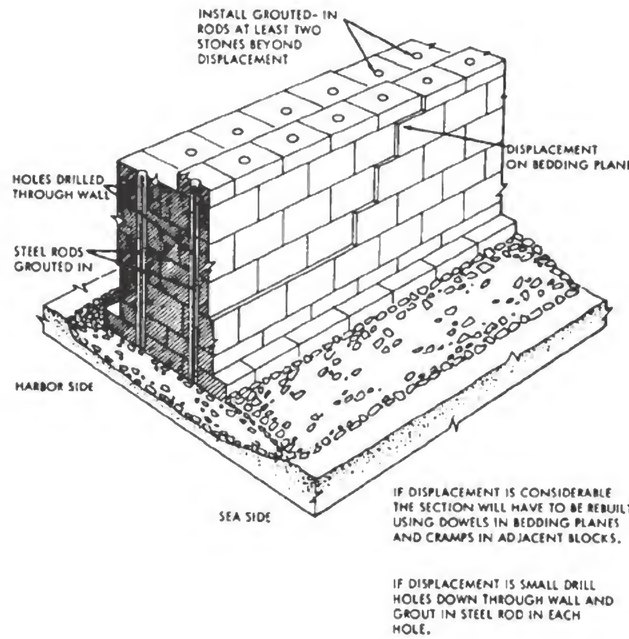
Structures made of cut stone and cast concrete, made in shapes and fitted up tightly together or laid up with mortar or similar material, are considered masonry structures. Units may be bonded together by overlapping, by metal clamps, dowels, bed plugs, or by shapes of the blocks. (See fig. 8-39.) All metal fastenings should be zinc-coated and well bedded in mortar. Sections of masonry that have washed out or have been damaged should be completely rebuilt, bonding the units to each other or using metal fastenings as necessary. Masonry walls that have cracked because of unequal settlement can be rebuilt; adding reinforcing bars as shown in figure 8-40. Repair of cracked walls should be delayed until settlement is complete, if possible. Where sections of walls have been displaced



117.291
Figure 8-39.—Anchoring masonry blocks.



117.292
Figure 8-40.—Repair to cracked masonry walls.



117.293
Figure 8-41.—Reinforcing vertical walls.

by sliding, an investigation should be made to determine the cause before it is rebuilt. If water builds up back of walls, the weep holes should be cleaned and new ones installed to relieve the pressure. Walls that fail because they are inadequate should be redesigned before they are rebuilt. It is advisable to provide clamps for reinforcement where the displacement of a wall is minor. If it is not necessary to rebuild the wall, it can be reinforced by drilling holes down through the wall at the area of displacement and a short distance beyond, inserting steel rods in the holes and filling the holes with cement mortar. (See fig. 4-41.)

Earth Structures

The use of earth for waterfront structures is confined largely to dikes and levees. It is also used for the interior of such structures as causeways, moles, and breakwaters; as backfill for quay walls and similar structures; and for fill for caissons and cellular structures. Earth that is exposed to wave action must usually be protected by riprap, cut stones, concrete blocks, or similar materials. The washing away of this protection exposes earth to erosion by rain, waves, and currents. When the earth is eroded, it should be replaced and wall-compacted prior to replacing the protecting material. Where earthfill is supported by a bulkhead, cell, caisson, or similar structure, the supporting structure should be repaired and the fill replaced in layers, with the coarser materials next to the bulkhead and the finer materials inboard. Layers must be compacted and consolidated. All materails for dikes and levees should be impermeable to prevent water from working through the structure. Vegetative covering is usually grown on the sides and top of earth structures to prevent erosion. Areas where vegetation has died or been damaged should be replanted.

CHAPTER 9

FOREMANSHIP

Whenever it is proposed that a group of individuals perform a construction (or any other) function, the steps in the project must be PLANNED, and the individuals who will perform them must be ORGANIZED and SUPERVISED. The term FOREMAN is the title commonly given in the construction and manufacturing fields to the individual responsible for planning the steps in a project (or a phase of a project), and for organizing and supervising the project personnel.

Information on planning is provided in chapter 2 of this manual. This chapter deals principally with organization and supervision. The chapter begins with a discussion of principles, and continues with a description of techniques. The term PRINCIPLE (as used in this chapter) might be considered similar to the military term STRATEGY, while the term TECHNIQUE has a close relationship to the military term TACTICS. Strategy comprises the broad, basic laws of war, as they have evolved through reason and experience. Tactics comprises the particular actions which should be taken by a unit in the field. The purpose of tactical action is to attain the ends dictated by strategical considerations.

Principle, similarly, means the broad, basic rules for a nonmilitary action. Techniques are the particular actions taken to attain the ends determined by principle. Strategy/principle must be broad enough to apply in most variations of circumstance. Tactics/techniques vary with varying circumstance. In the sections which follow immediately, the principles of organization and supervision will be discussed. After that, an attempt will be made to relate these principles to the organization and supervision of construction crews. Here we shall be discussing particular activities, or techniques.

PRINCIPLES OF ORGANIZATION

As the term is used in this chapter, "organization" means principally the intelligent division of labor. Division of labor is best exemplified by the assembly-line methods used in the automobile and other manufacturing industries. No single individual—probably no dozen individuals—could build as much as single automobile in a year. By dividing the labor—that is, by assigning each subphase of auto construction to an individual who repeats that one subphase on each car that comes along—the production of a number of cars a day by a relatively small number of workers is made possible.

The basic steps in organizing for this division of labor are about as follows:

1. Breaking down the manufacture of a complete automobile into a succession of subphases, each capable of being performed by a single individual.
2. Selecting, assigning, instructing, training, and equipping the individuals who will perform the subphases.

Organization for auto manufacture is a pretty extensive operation compared to the organization of a construction crew. However, the organization of a construction crew involves the same two fundamental steps. Now for the principles involved.

UNITY OF COMMAND

UNITY OF COMMAND may be defined as the principle which holds that each individual in an organization should be responsible to only a SINGLE superior. The principle should be applied in two ways:

1. Each man should know from whom he receives orders, and to whom he reports results.
2. Each man should know who the people are (if any) over whom he himself has control.

To achieve unity of command, lines of communication in an organization must be definite, clear cut, and SHORT. Organization charts and

lists of the duties and responsibilities of each individual in the organization must be prepared.

LIMITED SPAN OF CONTROL

The principle of LIMITED SPAN OF CONTROL means that a group should be organized in a manner which will ensure that the span of control of each supervisor in the group has reasonable limits with regard to number of personnel, distance, and time.

The reasonable number of people directly supervised will vary, of course, with the nature of the project. However, the general average seems to be not fewer than three and not more than seven subordinates. A supervisor stationed over less than three subordinates is usually not making full use of his capacities. One supervising more than seven is often unable to supervise them all efficiently.

With regard to distance, it is unwise for a subordinate to be either too close to or too far away from his supervisor. Having a subordinate too close usually results in excessive supervision. Having one too far away may result in undersupervision, in which case the subordinate may begin to function independently of control. The ideal distance is the one which minimizes both oversupervision and undersupervision. It is more a matter of judgment than a measure of actual physical distance.

The time element involved in the principle of limited span of control must be considered in connection with the four principal types of supervisory duties, which are as follows:

1. ROUTINE duties. These are duties which a supervisor may assign to subordinates—remaining responsible himself, of course, for their being carried out. The cleaning of tools is an example.
2. REGULAR duties. These comprise the normal supervisory activities relating to the project. Checking on crews for the use of proper, efficient, and safe working methods is an example.
3. SPECIAL duties. These relate to special assignments, outside the regular run. They may be assigned from higher up, or they may be initiated by the supervisor himself. Requiring, as a safety measure, that a man who has been injured through negligence explain the accident to the other crew members, and describe the precautions which should have been taken, is an example of a special duty originating with the supervisor himself.
4. CREATIVE duties. These involve actions taken on the supervisor's own initiative to improve the quantity and quality of the work. Ordering a shift from brush painting to spray painting for a structure which could be much more quickly and thoroughly sprayed than brushed is an example.

The time element in the principle of unity of command simply means that a project must be organized so that, for every supervisor, the daily time required for complete carrying out of each of these four types of duties will neither exceed nor fall short of the total on-the-job time of the supervisor.

HOMOGENEOUS ASSIGNMENTS

HOMOGENEOUS means, in general, "having similar characteristics." The principle of homogeneous assignments means that workers performing similar functions should be grouped together, and that functions should be scheduled in logical relationship sequence so that each operation performed is a successive step toward completion. Also, if an individual is assigned more than one task, the second task should be one which employs, as nearly as possible, the same knowledge and skills required for the first; and the second should be a task to whose completion the first contributes. The practice of assigning nonhomogeneous details as secondary duties is a common mistake.

DIVISION OF LABOR

We previously mentioned, as an example of division of labor, the assembly-line method of the auto industry. This is only one of three commonly used systems; it is the first of the three following:

1. The SERIES or ASSEMBLY-LINE system. In this system the structural materials flow from one person to another, with each person repeating the same designated segment of the work. Individual jobs are for the most part simple, requiring relatively little training and skill.

2. The PARALLEL system. In this system each worker performs a whole operation—that is, working independently he turns out a complete product by performing all the required production steps. This system is limited mostly to artistic or craft work.

3. The UNIT-ASSEMBLY system. In this system several employees work together as a crew on one item from start to finish, with each crew turning out a complete product, or a major phase of a complete product.

As you can see, the nature of the construction industry usually calls for the application of the unit-assembly system. Builder crews perform most of the structural erection on a project; utility crews install all the utilities from start to finish. Disadvantages of the system include long transportation time (to sites which cannot, as in the assembly-line system, be brought to the workers), and uneven distribution of work. Uneven distribution of work occurs when, for example, a phase to be performed by a crew must be held up until a phase being performed by another crew is completed. Careful planning is called for to reduce the idle time caused by this disadvantage.

PRINCIPLES OF SUPERVISION

A First Class or Chief Builder serving as project foreman is a SUPERVISOR rather than a MANAGER. The distinction lies in the fact that a supervisor is in direct contact with, and has direct control over, the individuals who are engaged in the actual work of production. Management, on the other hand, is control once removed. To put it another way: management exercises control through supervisors, while supervisors exercise direct control.

SUPERVISORY DUTIES AND RESPONSIBILITIES

The major duties and responsibilities of a supervisor may be broadly stated as follows:

1. Production.
2. Safety, health, and physical welfare of subordinates.
3. Development of cooperation.
4. Development of morale.
5. Training of subordinates.
6. Paperwork (Records, reports, job orders, etc.)

These might be considered the broad principles of supervision. A detailed list of the techniques involved in applying these principles could be made only with regard to the supervision of a particular project. However, the following techniques have pretty general application:

1. Getting the right man on the job at the right time.
2. Maintaining quality and quantity in production.
3. Planning and encouraging teamwork.
4. Attendance control.
5. Keeping subordinates satisfied and happy on the job.
6. Maintaining discipline.
7. Settling differences among subordinates.
8. Adjusting grievances.
9. Maintaining good job housekeeping.
10. Keeping records and making reports.
11. Developing and maintaining cooperation with other crews.
12. Preparing and disseminating rules, organization charts, work procedures, and the like.
13. Planning and scheduling work.
14. Giving orders and directions.
15. Providing organized and unorganized training.
16. Requisitioning tools, equipment, and materials.
17. Economical use and placement of materials.
18. Checking and inspecting materials.
19. Inspection, care, and preservation of tools and equipment.
20. Accident prevention, by safety training and control of hazards.

Of the six major supervisory duties and responsibilities, No. 4 (development of morale) is pretty well covered in Military Requirements for Petty Officer 3 & 2 and Military Requirements for Petty Officer 1 & C. This leaves the others to be discussed here.

Production

The primary responsibility of every supervisor is PRODUCTION. This responsibility is carried out in three ways, as follows:

1. By planning and organizing the work to get maximum production with minimum effort and confusion.
2. By delegating as much authority as possible, while of course remaining responsible for the final product.
3. By continuous supervision and control to ensure that the work is done properly.

Safety, Health, and Physical Welfare of Subordinates

Safety and production go together, since the only efficient way to do anything is a safe way. When men are absent because of injury, or equipment is down because of damage, or completed work is destroyed by accident, then production drastically falls. Therefore, a good supervisor is a constant preacher of safety; he sets an example by conscientiously observing all safety precautions himself; he teaches safety as an integral part of each training unit; and he plans every job with safety in mind.

Showing concern for the health and physical welfare of subordinates also pays off productionwise. A healthy worker in a state of good physical being is inherently a more efficient worker than one who doesn't enjoy these advantages. Besides, concern for these things is bound to increase the favor with which a subordinate views his superior, and motivate the subordinate to additional effort.

Cooperation

The necessity for developing cooperation between the members of a supervisor's own crew is obvious enough. Some supervisors, however, tend to overlook the necessity for cooperation in two other directions, which are:

1. Cooperation with management.
2. Cooperation with the supervisors of other crews.

Cooperation with management means, principally, keeping management (meaning usually the project and battalion officers concerned) continually informed of circumstances which (1) require decisions or other actions of management, and (2) would be unknown to management in the absence of reports or other information from supervisors. It is often the case that what a supervisor (and perhaps his men as well) imagine to be the indifference of management is actually a result of the fact that management is ill-informed of the circumstances.

Cooperation with the supervisors of other crews is of prime importance in the construction field. The reason is the extent to which, on a given structure, the work of one group is interdependent on the work of other groups. For example: in structural work erected under the supervision of the Builders there must nearly always be openings left, or other provisions made, for the installation of plumbing and electrical features. In many cases, certain phases of the structural work must be postponed until after plumbing or electrical features are installed. Working drawings for Builders may show in general the nature of the provisions for plumbing and electrical installation. To get a clear picture, however, of just what should be done and when, a Builder supervisor should have the advise of, and cooperate continually with, the plumbing supervisor.

It is easy to imagine the effect on production of (for example) the necessity for chopping a hole through a long-since-hardened reinforced concrete wall to admit a water pipe or electrical conduit, or of the necessity for dismantiling part of an erected structure to accommodate plumbing or electrical installation.

Particularly important, too, is constant cooperation between the Builder supervisor and the battalion's Field Engineering Section. The Field Engineering Section, supervised usually by an Engineering Aid, has, among other duties, the duty of establishing lines and grades for crews engaged in structural work. The number of field parties available in the section is limited. For example, suppose a Builder supervisor has forgotten to arrange for a stakeout of some phase of construction, but has a crew ready to start to work. At this time he must request a survey party to stakeout lines right away. However, it is not usually the case that such a party can be provided right away. The result is idle time for a Builder crew and a falling off in production.

Training

There is no "best" method for training that applies to every situation. However, a number of pointers can be given which generally can be used as a guide to effective organization of training material.

For one thing, make sure your material is complete. Omit no steps or significant information. Arrange material in a systematic and orderly manner, so that each step rests securely upon information already provided. Avoid overlapping, since too much repetition is a waste of time, and usually leads to inattention on the part of the trainees.

For our purpose here, we will discuss briefly two categories of training: ON-THE-JOB and FORMAL training.

There are many forms of ON-THE-JOB training. It may be in the form of an especially tailored, well-organized program, such as one

designed to help Builders acquire advanced skills in building. Then again, on-the-job training may be in the form of simple instruction, like explaining and showing a man how to cut and prepare a certain joint. In other words, when one man helps another learn to do a job and makes sure he learns the right way, it is a form of on-the-job training.

You may not have realized it, but in the Seabees on-the-job training goes on about all the time. For instance, two BUs were assigned the job of fabricating a door and frame of a certain design. Although they had performed many comparable jobs, they had not done that particular one. Their supervisor assigned an experienced man to guide them. He explained the exact procedure for laying out the component parts, how they were formed, how they were fastened, and why that particular design was necessary. The BUs understood and easily proceeded with the job.

There are as many examples of on-the-job training as there are contacts between personnel in the Seabees. The importance of on-the-job training becomes readily apparent in an organization such as the Seabees, where changes in equipment, personnel, and materials call continuously for new and better methods of doing things.

In the Seabees, as well as in private industry, the term on-the-job training has come to mean "helping an individual acquire the necessary knowledge, skill, and habits to perform a specific job." This definition implies that the job training applies not only to the Constructionman or new men in an organization, but also to any person who is assigned a new job. It indicates that job training is a continuous function in the Seabees. No person should be regarded as completely trained. His performance can always be improved by keeping his interest high and by passing on to him directions, suggestions, and information which will increase his proficiency.

Bear in mind, however, that on-the-job training is an active process and requires active supervisors who are aware of the needs of the trainees and can motivate them to learn. Methods must be utilized which will add meaningful experiences to the trainees' storehouse of knowledge.

A supervisor who does a good job of training his men stands to benefit in many ways. For one thing, a well-taught man brags about his supervisor, especially to his buddies in other crews. A remark he might make proudly is that "I sure enjoy working for Dewey Kemp because he teaches me so much." As you can see, this will multiply your effectiveness on the crew. When you teach 10 men a skill, you are multiplying your effectiveness 10 times.

FORMAL training generally takes place during regularly scheduled training periods during the workday, and it may or may not be voluntary on the part of the trainees participating. Such training usually is in a group or classroom instructional setting.

Broken down as to subject matter, formal training may be arbitrarily divided into two areas:

1. Subject matter required for advancement. Here the instructing petty officer conducts training in general subject matter areas, such as mathematics or blueprint reading. In this training situation, men from other Construction ratings will also likely participate, because knowledge of (for example) mathematics is a requirement for several ratings. At other times, the instructing petty officer may lecture and demonstrate to BU strikers on such subjects as joint framing, concrete finishing, and leveling.

2. Subject matter required for the solution of an immediate problem which may or may not have a bearing on rate training. The predeployment training of the detachment that participated in Deepfreeze Operation II is an example. Group training where work simplification is necessary to make work schedules mesh—as when Builders, Steelworkers, and Utilitiesmen working on a common job run into dead time because one of the groups, or perhaps all three, are using cumbersome work techniques—is another.

Paperwork

As a BU1 or BUC, you can expect paperwork to be an important part of your job. For instance, you will likely be responsible for the preparation of inspection and progress reports of construction jobs. You will also have to prepare job orders and material requisitions. Other paperwork duties may include keeping various logs, charts, graphs, and so on, for your own personal use. See that these and other paperwork duties which could be mentioned are handled carefully and properly.

While you may not especially like paperwork, remember that various records, reports, and so on, often are necessary to make sure a project is completed properly and on time. Make it a practice to keep neat, accurate records and reports; and see that each is submitted by the

date due. Have a place for file copies of records and reports; then if you need to obtain information from them, you will know just where to look.

We will not attempt to explain all the paperwork duties involving your job in this training course. Detailed information on job orders, however, is given in the following section; and, various reports that you may prepare in different assignments are mentioned later in the chapter. Information in chapter 3 will also be useful in paperwork duties involving scheduling, including the Critical Path Method.

Job Orders

Job orders are issued primarily for the purpose of specifying what work is to be done and when it is to be accomplished. The job order also serves to provide for the accumulation of cost data. As a supervisor most of the work performed by the personnel under your supervision will involve the use of job orders. As a BU1 or BUC, you may often be involved in the preparation of job orders. Since the procedures used in the work order system will not be the same at all activities, you must learn the procedures for your activity and follow them carefully.

Job orders usually originate from some form of work request. As it may be easily seen, chaotic conditions would exist if established procedures permitted CM3 Anderson to request a new messhall and BUCS Collins to approve the request and issue the job order. We would, however, be no better off if the Commanding Officer were required to request the repair of a broken water main and forward the request to Congress for approval. Therefore, a work control system is established to designate who may request work, what they may request, and the person who will approve the request authorizing the job order. In the Public Works Department the control and responsibility is usually designated within the framework of the Work Classification System. Public Works uses eight classifications of work:

(1) Emergency Work
(2) Service Work
(3) Minor Work
(4) Specific Jobs
(5) Standing Jobs
(6) Supplements to Authorized Work
(7) Amendments to Authorized Work
(8) Rework

EMERGENCY WORK is work that requires immediate action to accomplish any or all of the following purposes involving Public Works and/or Public Utilities:

1. Prevent loss or damage to government property.
2. Restore essential services that have been disrupted by a breakdown of utilities.
3. Eliminate hazards to personnel or equipment.

Emergency Work Authorizations are limited to two man-days; the Emergency Work Authorization must be superseded by a Minor Work Authorization or by a Specific Job Order, whichever is appropriate.

SERVICE WORK is work that is relatively minor in scope, is not emergency work by nature, and does not exceed the dollar limitations which the Work Reception and Control Unit is authorized to approve ($75 to $150, depending upon the size of the activity).

MINOR WORK is work that is in excess of that authorized by an Emergency/Service Work Authorization and less than that authorized by a Specific Job Order.

SPECIFIC JOB ORDERS are those orders authorizing the accomplishment of a specific amount of work for which individual job costs are desired for financial and performance evaluation.

STANDING JOB ORDERS include all work that is highly repetitive or for which it is desired that cost be accumulated for a specified period, usually a fiscal year. Some examples where Standing Job Orders are used are: trash and garbage disposal, power plant watch standing, Public Works engineering, leave cost and shop overhead.

SUPPLEMENTS TO AUTHORIZED WORK are issued for any portion of the work under a basic job order that is to be initially charged to an accounting classification other than that shown on the basic job order. A Supplementary Job Order may be issued under a specific or standing job order.

A Specific, Standing or Supplementary Job Order may use an AMENDMENT TO AUTHORIZE WORK for various reasons including:

1. To reopen a closed job order.
2. To modify the technical provisions.

3. To increase or decrease the scope.
4. To increase or decrease the dollar estimate.
5. To change the accounting classification.

REWORK is work that, in the judgment of the Public Works Officer, is necessary to correct faulty work of Public Works Department personnel.

Certain types of work require prior approval of authorization of the Commanding Officer, management bureau, or higher authority, but the issue of the job authorization to the Public Works shop is the responsibility of the Public Works Officer or his delegated representative. Although job authorization is, in effect, the actual signing of the authorizing document, the act presupposes knowledge and approval of every item contained in the work authorization document. Job authorization, therefore, presumes an understanding of the principles and workings of Controlled Maintenance, as well as familiarity with the action to be approved. The following persons have direct or delegated authority to sign work authorization documents and/or to approve the performance of work as noted.

The PUBLIC WORKS OFFICER may approve and sign any or all work authorizations within the limitations established by the cognizant management bureau or the Commanding Officer. In actual practice, the Public Works Officer usually approves and signs only those documents authorizing work that exceeds the limitations for authorization established by him for the Director of the Maintenance Control Division.

The ASSISTANT PUBLIC WORKS OFFICER may approve and sign any or all work authorization documents when such authority has been specifically delegated by the Public Works Officer.

The DIRECTOR, MAINTENANCE CONTROL DIVISION may approve and sign any or all work authorization documents not exceeding the monetary limitations for authorization imposed by the Public Works Officer.

The SHOPS ENGINEER may approve Minor Work, Service Work and Emergency Work Authorizations.

The DIRECTOR OF THE MAINTENANCE OR UTILITIES DIVISION may approve Minor Work, Service Work, and Emergency Work Authorizations.

The WORK RECEPTION AND CONTROL BRANCH (MAINTENANCE CONTROL DIVISION) may approve and sign Emergency Work and Service Work Authorizations within the limits established by the Public Works Officer.

At times, it may be necessary for you to make up work requests or job orders. Requests for all work, except Service and Emergency, are made on a "Work Request (Controlled Maintenance)," NavDocks 2351 (see fig. 9-1) or "Inspectors Report," NavDocks 25-3. Job orders from these requests are prepared on a "Job Order," NavDocks 2356 and a continuation sheet, NavDocks 2357 (see fig. 9-2). For Emergency or Service work an "Emergency or Service Work Authorization," (NavDocks 2358, is used; this form is illustrated in figure 9-3). The work request becomes the job order when it is authorized.

In making up a work request or a job order be sure that a clear description of the work is given and all necessary drawings and details are included.

You may be with a MCB working with job orders dealing with Military Construction (MILCON). A typical job order from a NCR to a MCB is presented in figure 9-4. The job order form is explained below.

WORK ORDER NUMBER: An assigned accounting number used to control and accumulate charges of materials and labor against the project.

LINE ITEM: The MILCON Line item number which identifies the particular project.

JOB TITLE: A short general title of the work to be performed.

DOD CAT CODE: The DOD Facility category code under which the work is being assigned.

QUANTITY: The scope of the facility being constructed in terms of DOD category units of measure.

ESTIMATED MAN-DAYS: An estimate of direct man-days required to do the work described.

ESTIMATED COST: Dollar cost estimated to complete project.

CUSTOMER ACTIVITY: The activity or command for whom the work is to be performed.

REPRESENTATIVE: An official designated to provide liaison between the construction unit and the customer.

TELEPHONE: The telephone number of the representative.

DESIGNATED FOR ACCOMPLISHMENT: Construction unit which is to perform the assigned task.

AUTHORIZED BY: Name and signature of the authorizing official.

GENERAL DESCRIPTION AND REMARKS: A brief, general description of the work and

WORK REQUEST (MAINTENANCE MANAGEMENT)
NAVFAC 9-11014/20 (REV. 3-68) S/N-0105-002-7510
Supersedes NAVDOCKS 2351

(PW Department see Instructions in NAVFAC MO-321)

Requestor see Instructions on Reverse Side

PART I—REQUEST (Filled out by Requestor)

1. FROM Supply Officer	2. REQUEST NO. 12-711
3. TO Public Works Officer	4. DATE OF REQUEST 26 June 1968
5. REQUEST FOR ☐ COST ESTIMATE ☒ PERFORMANCE OF WORK	5a. REQUEST WORK START
6. FOR FURTHER INFORMATION CALL LTJG L. Moore Bldg. C. Ext. 891	7. SKETCH/PLAN ATTACHED ☐ YES ☒ NO

8. DESCRIPTION OF WORK AND JUSTIFICATION (Including location, type, size, quantity, etc.)

Fabricate and erect extension to wood storage rack, southwest corner, Bldg. 107. Start from the south wall and extend through bays 3-4 approx: 30' long
2' deep
10' high

Storage rack to be anchored to wall and have 5 shelves spaced approx. 2' apart. Shelves should be capable of storage of material weighing up to 5 lbs. per sq. ft. No paint required.

Extra storage space needed for small shop store items.

9. FUNDS CHARGEABLE 37602 (S&A)	10. SIGNATURE (Originating Official) J. R. Brown J. R. BROWN, LCDR, USN

PART II—COST ESTIMATE
(Filled out by Maintenance Control Division if estimate requested)

11. TO Supply Officer	12. ESTIMATE NO. 307

13. COST ESTIMATE	
a. Labor	$ 140.
b. Material	$ 90.
c. Overhead and/or Surcharge	$
d. Equipment Rental/Usage	$
e. Contingency	$ 25.
f. TOTAL	$ 255.

14. SKETCH/PLAN ATTACHED ☐ YES ☒ NO

15.
☐ APPROVED. PROGRAMMING TO START IN ______
☒ APPROVED. BASED ON PRESENT WORKLOAD, THIS JOB CAN BE PROGRAMMED TO START IN 30 days, IF AUTHORIZED BY 25TH OF July AND FUNDS ARE MADE AVAILABLE.
☐ DISAPPROVED. (See Reverse Side)

16. SIGNATURE William B. King	17. DATE 3 July 1968

PART III—ACTION (Filled out by Requestor)

18. TO
Public Works Officer

19. AUTHORIZATION TO PROCEED IS ATTACHED (Check one if other than PW funds are involved) ☒ NAVCOMPT 140 ☐ OTHER	20. WORK REQUESTED ☐ HAS BEEN CANCELLED ☐ HAS BEEN DEFERRED ☐ WILL BE PERFORMED BY OTHERS
21. SIGNATURE J. R. Brown J. R. BROWN, LCDR, USN	22. DATE 8 July 1968

(See Part IV on Reverse Side)

117.294
Figure 9-1. — Work Request (Controlled Maintenance), NavDocks Form 2351.

JOB ORDER (CONTROLLED MAINTENANCE)

			3. JOB ORDER NO. 7312011
			4. SHOP CONTROL NO.
1. ACTIVITY Naval Station Anywhere		2. ACTIVITY CODE	5. ESTIMATE NO. 436
6. ACTIVITY ACCOUNTING NO. 62690	7. BUDGET FUNCTION CODE	8. W. M. CODE 114	9. PROPERTY NO. 32
10. APPROPRIATION 1721804	11. SUBHEAD 2515	12. ALLOTMENT-PROJECT 12008	13. EXPEND. ACT 44540
14. FOR FURTHER INFORMATION CALL:			15. SKETCH/PLAN ATTACHED ☒ YES ☐ NO
16. GENERAL JOB DESCRIPTION	17. Bus Labor Class Code 07		COMMITTED STARTING DATE 1 May 196–

Convert Storehouse, Bldg. 32 into three office areas (60'x30'ea) by installing two partitions, each with center door. Install new lighting with outlets, abandon old concealed wiring. Install steam radiators Install water coolers. Paint office surfaces including doors, sash and trim, two coats. Lay asphalt tile over present wood floor. Paint Bldg. exterior.

18. BREAKDOWN OF WORK

a. WORK CENTER	b. DESCRIPTION	c. EST. HOURS
02	Construct and erect 60 linear feet of 12' high full partition sheathed with gypsum wall board on both sides, 2"x4" frame Studs 16"o.c. 5" baseboard with shoe moulding, shoe moulding to be set loose. 3" cove ceiling moulding. Install 6'-8" x 2'-8" door (flush type) in center of new partition. 4" chair rail to be installed on wall.	
	For continuation see Sheets 2 through 3	

19. SUMMARY OF ESTIMATES

a. WORK CENTER	b. LABOR HOURS	c. LABOR $	d. MAT'L $	e. TOTAL EST $
02*	308	647	484	1,131
03*	406	840	296	1,136
07*	29	60	835	895
12*	153	329	1,372	1,701
14*	8	13	7	20
15*	74	161	175	336
TOTAL	978	2,050	3,169	5,219
f. CONTINGENCY				
g. OVERHEAD AND/OR SURCHARGE				
h. GRAND TOTAL				5,219

20. DISTRIBUTION

INSP	1	FISC	1
MCO	1	MAINT	12
PW	1		
M.A.S.	1		

21. AUTHORIZED WORK TO BE PERFORMED (Signature) B.W. Wadsworth — 22. DATE 1 Mar. 196–

SHEET 1 OF 3

JOB ORDER CONTINUATION SHEET (CONTROLLED MAINTENANCE)

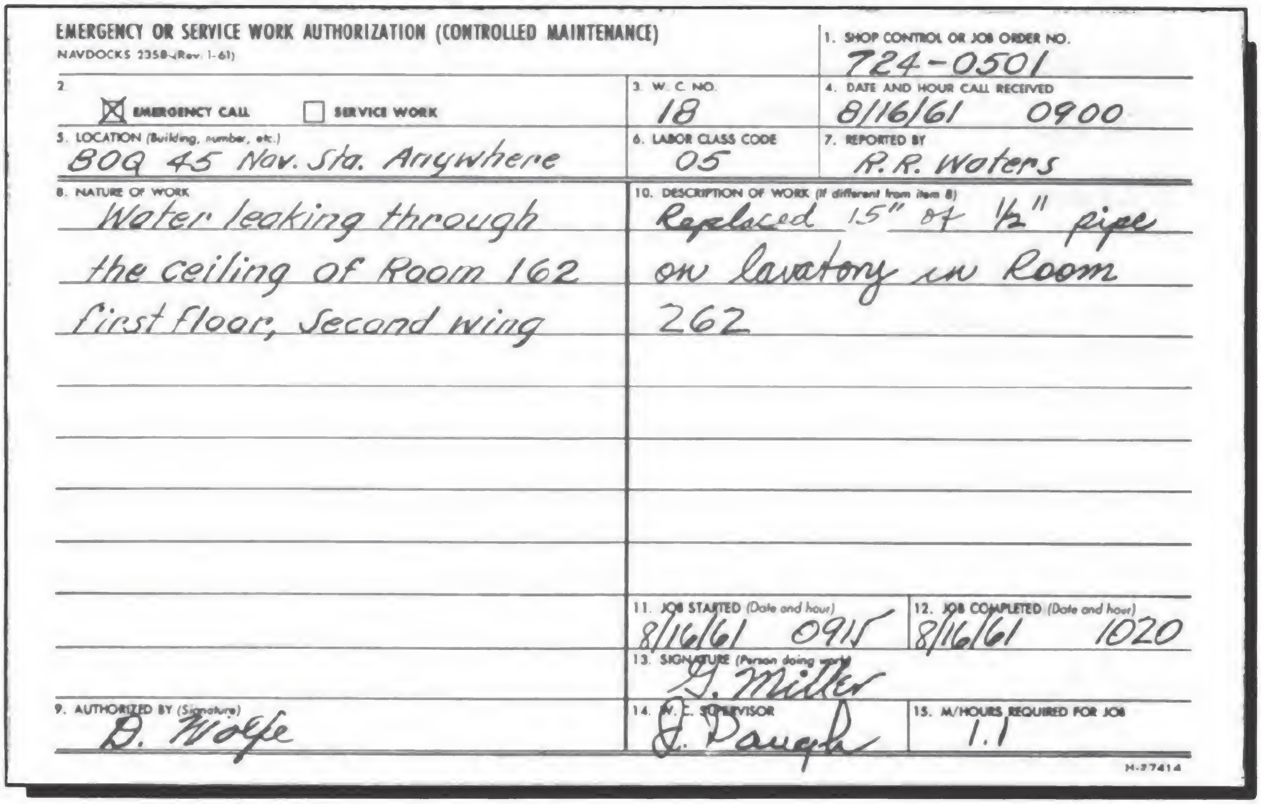
1. JOB ORDER NO. 7312011 — 2. ESTIMATE NO. 436 — 3. SHOP CONTROL NO.

4. WORK CENTER NUMBER	5. DESCRIPTION OF WORK	6. ESTIMATED HOURS
02	Lay 5300 sq. ft. of 9"x9" asphalt tile with 15# asphalt felt base on existing wood floor. Existing loose floor structure to be renailed and rough sanded before cementing 15# felt. Base board shoe moulding to be reset upon completion of tile application.	228
03	Prepare, prime and paint all partition surfaces. Clean, prime and paint all interior original surfaces in office sections. Paint ceiling, sprinkler pipe, ceiling moulding, door, casing and baseboard flat white. Walls above dado, ceiling moulding, light green. Paint dado walls including chair rail, baseboard, shoe moulding, doors, windows, casing and trim, dark green. Paint for all wall surfaces, trim, etc. to be semi-gloss. Paint exterior of building one coat of existing color.	406
12	Install and connect 52 stem mounted, 4 tube 48" louvered fluorescent light fixtures and 12 duplex convenience flush mounted outlets. Lights to be located 18" below ceiling and outlets to be located 16" above floor. Old lights to be removed, boxes capped, circuits disconnected and abandoned in place.	39
15	Install and connect four sectional type cast iron radiators. Provide traps for each radiator.	11
07	Install and connect three water coolers. Provide traps on new waste lines and valves on new supply lines.	5
14	Remove and properly dispose of debris and extra material discarded in, around and under the building as a result of this work	8

Sheet 3 of 3

87.4

Figure 9-2.—Job Order (Controlled Maintenance), NavDocks Form 2356.



EMERGENCY OR SERVICE WORK AUTHORIZATION (CONTROLLED MAINTENANCE)
NAVDOCKS 2358 (Rev. 1-61)

1. SHOP CONTROL OR JOB ORDER NO. 724-0501
2. [X] EMERGENCY CALL [ ] SERVICE WORK
3. W. C. NO. 18
4. DATE AND HOUR CALL RECEIVED 8/16/61 0900
5. LOCATION (Building, number, etc.) BOQ 45 Nav. Sta. Anywhere
6. LABOR CLASS CODE 05
7. REPORTED BY R.R. Waters
8. NATURE OF WORK Water leaking through the ceiling of Room 162 first floor, Second wing
9. AUTHORIZED BY (Signature) D. Wolfe
10. DESCRIPTION OF WORK (If different from item 8) Replaced 15" of 1/2" pipe on lavatory in Room 262
11. JOB STARTED (Date and hour) 8/16/61 0915
12. JOB COMPLETED (Date and hour) 8/16/61 1020
13. SIGNATURE (Person doing work) G. Miller
14. W. C. SUPERVISOR J. Daugh
15. M/HOURS REQUIRED FOR JOB 1.1

H-27414

117.295

Figure 9-3.—Emergency or service work authorization (Controlled Maintenance), NavDocks Form 2358.

other pertinent data, such as i.e. special specifications.

REFERENCE: Identification of reference pertaining to the construction project.

ENCLOSURE: Identification of drawings, specifications, etc., that are being forwarded with the work order.

INSTALL TASK NO.: Numerical identification of sub-tasks to be performed by the construction unit in completing the assigned project.

WORK CLASS: Indication of the predominate ratings involved in the sub-task.

DESCRIPTION OF WORK ACCOMPLISHED: Short description of sub-task.

MAN-DAYS: Estimated or actual number of direct man-days required to complete the sub-task.

BEGIN DATE: Estimated or actual calendar date upon which work on the sub-task will commence.

FINISH DATE: Estimated or actual calendar date upon which work on the sub-task will be completed.

SIGNATURE AND DATE: Signature of construction unit representative and date of signature.

When you, as a supervisor, receive a job order, examine it carefully. Make sure you have a clear picture of what is to be done, who is to do it, and when. See that you also have all the information necessary to do the job. If material listings and drawings are listed on enclosures, make sure that they have been included and check them for accuracy. If you have been designated as prime contractor or lead shop, see that the subcontractors or other shops have received the job order, prints, and material list as required. Check the availability of the material. The material support will vary greatly. On some jobs you may not receive the job order until after all the materials necessary

THIRTIETH NAVAL CONSTRUCTION REGIMENT

EST MD 2,000

WORK ORDER NUMBER	JOB TITLE	ESTIMATED COST
6PPP69901	TWENTY FIFTH MOUNTED POLICE BATTALION CANTONMENT, OTTAWA	$26,000
LINE ITEM C-777	DOD CAT CODE 699 QUANTITY 700 MN	DATE 22 July 1966

CUSTOMER
ACTIVITY 25th MOUNTED POLICE BATTALION

REPRESENTATIVE FIELD COPPBOO BOO

TELEPHONE OTTAWA 4

DESIGNATED FOR ACCOMPLISHMENT

Mobile Construction Battalion SEVENTY-FIVE

AUTHORIZED BY:

GENERAL DESCRIPTION AND REMARKS

Construct the following facilities for customer unit in accordance with reference (a):

(1) Eighty-two (82) 16' x 32' Metal roofed strongbacks.
(2) Three (3) 8 Hole latrines.
(3) One (1) 20' x 48' Shower with concrete deck.
(4) One (1) 500 Man Galley.

Site location as shown by enclosure (1).

REFERENCE:
(a) 25th MOUNTED POLICE BN LTR DTD 25 MAY 66 SER 0000.

ENCLOSURE:
(1) BASE DEVELOPMENT DWG 732

INSTALL TASK NO.	WORK CLASS	DESCRIPTION OF WORK ACCOMPLISHED	MANDAYS	DATE BEGIN	DATE FINISH
82 - 16' x 32' Strongbacks				25 JUN 66	5 AUG 66
1.	EO	Site Preparation	10		
2.	BU	Erection of Strongbacks	738		
3.	CE	Interior/exterior Wiring	72		
		TOTAL	820		
3- 8 Hole latrines				20 JUL 66	5 AUG 66
1.	BU	Erect three structures	54		
		TOTAL	54		
1 - 20' x 48' Shower with concrete deck				20 JUL 66	5 AUG 66
1.	BU	Concrete pour	10		
2.	BU	Erect building	70		
3.	UT	Install piping	10		
4.	CE	Wiring	10		
		TOTAL	100		
1 - 500 Man Galley				5 JUL 66	5 AUG 66
1.	EO	Site preparation	20		
2.	BU	Concrete pour	80		
3.	BU	Building erection	850		
4.	CE	Wiring	50		
		TOTAL	1000		
		GRAND TOTAL	1974		

SIGNATURE DATE

117.296.1

Figure 9-4.—Military Construction Battalion Job Order.

for the job have been received. On other jobs you may have to order the materials yourself through the use of a material yard, shop stores, or the Navy Supply System. If you have any questions, get them answered before starting the job.

See that all the material is properly charged to the correct job order number and that the material is used on the job for which it is drawn. Make sure, also, that the required labor is correctly charged. This will keep you from the embarrassing position of trying to explain how a job was completed without anyone working on it or why some other job exceeded by far the original time estimate.

Progress reports may be required for job orders in progress. These are usually submitted each work and are used to adjust work schedules. Usually, they should list each job in progress. They should also contain a brief description of work accomplished for that reporting period and a brief description of the work remaining. Sometimes this information may be reported simply as the percent of the job completed.

ORGANIZING FOR CONSTRUCTION

Figure 9-5 shows the overall organization of a standard Naval Mobile Construction Battalion (P-25), consisting of 563 officers and enlisted men. Primarily, the Builders are assigned to one of the two General Construction Companies, either Charlie or Delta Company. Here you will be further assigned to either the Wood Construction Platoon or the Concrete and Steel Construction Platoon, depending of course upon your Navy Enlisted Classification (NEC) or on previous experience.

Perhaps you have received training as a Millworker Technician. If this is the case, you will probably be assigned to Bravo Company (fig. 9-6) as the Carpenter Shop Supervisor. As a Builder Chief, you might supervise both the Carpenter and Steel Shops. Your men will perform all routine structural maintenance about the camp. They will fabricate cabinets, forms, trusses, and sheet metal ducts, and also perform other shop work, in support of the major construction projects.

One Builder Chief is generally assigned to the Headquarters Company's Operations Department as head of the Structural Section, Planning and Estimating Division. A Planning and Estimating NEC is generally required for this position. It is also possible, as a BUC, that you will be the Central Tool Room (CTR) Supervisor.

Upon advancement to Senior Chief Builder, you can expect to be Company Chief of either "C" or "D" Company, the current organization of which is shown in figure 9-7. Later, as a Master Chief Constructionman, you can look forward to the prestige and responsibilities of Operations Chief.

Under the Commanding Officer, the Operations Officer is responsible for construction operations. Under the Operations Officer there may be an officer assistant to oversee one or more of the design, engineering, planning and estimating, or materials procurement functions essential to production.

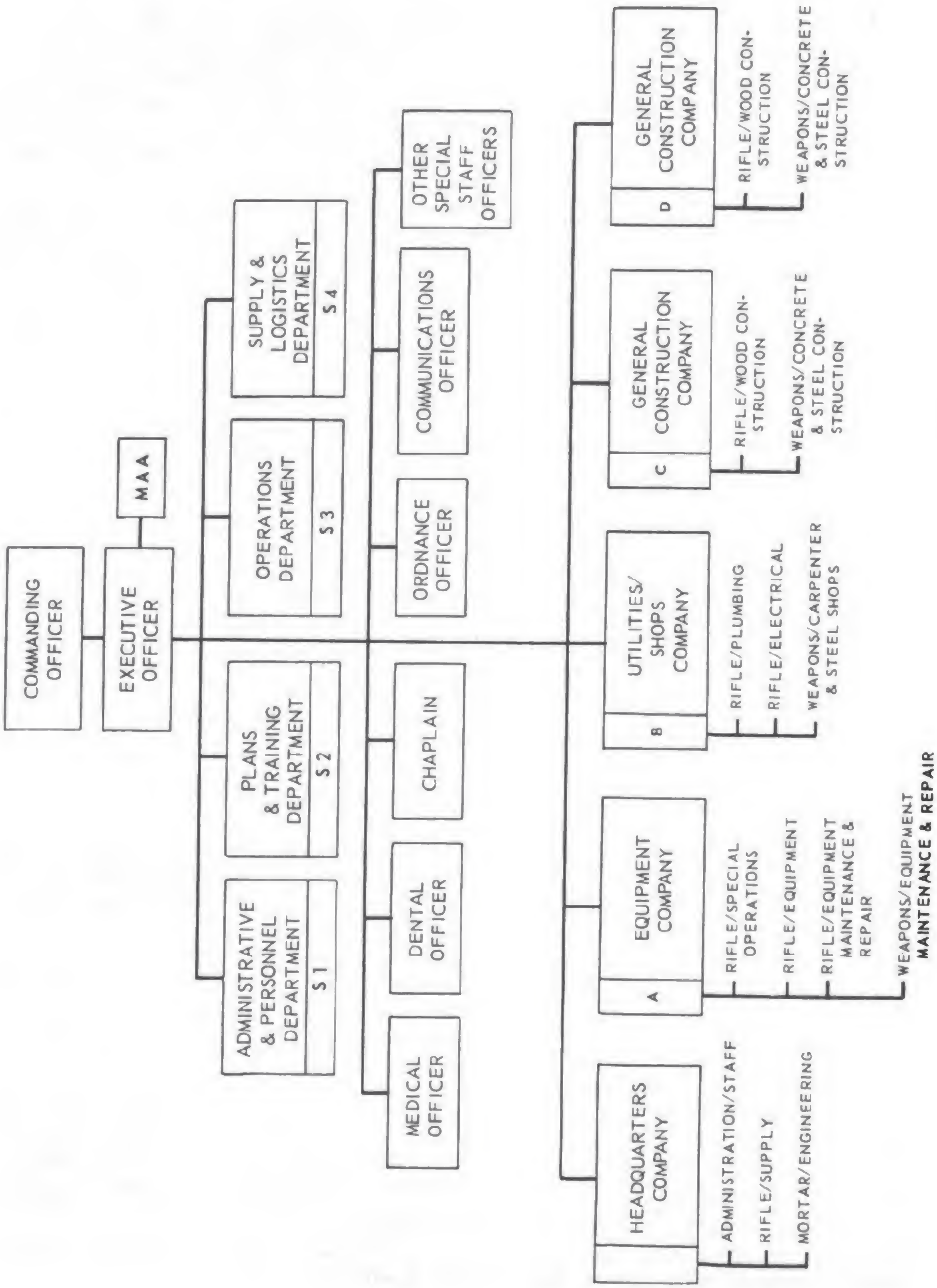
The engineering function of the Operations Department and the personnel assigned thereto include the following work of the Field Engineering, Inspection and Testing, and Progress Control Sections (the functions of these are explained in more detail later):

1. Topographic surveys and site reconnaissance as required.
2. Stakeout of work as required.
3. Measurement of work in place.
4. Other engineering services as required.
5. Inspection of all construction work performed by the battalion.
6. Soil tests, material tests, and other tests as required.
7. Ordering of construction materials.

FIELD ENGINEERING

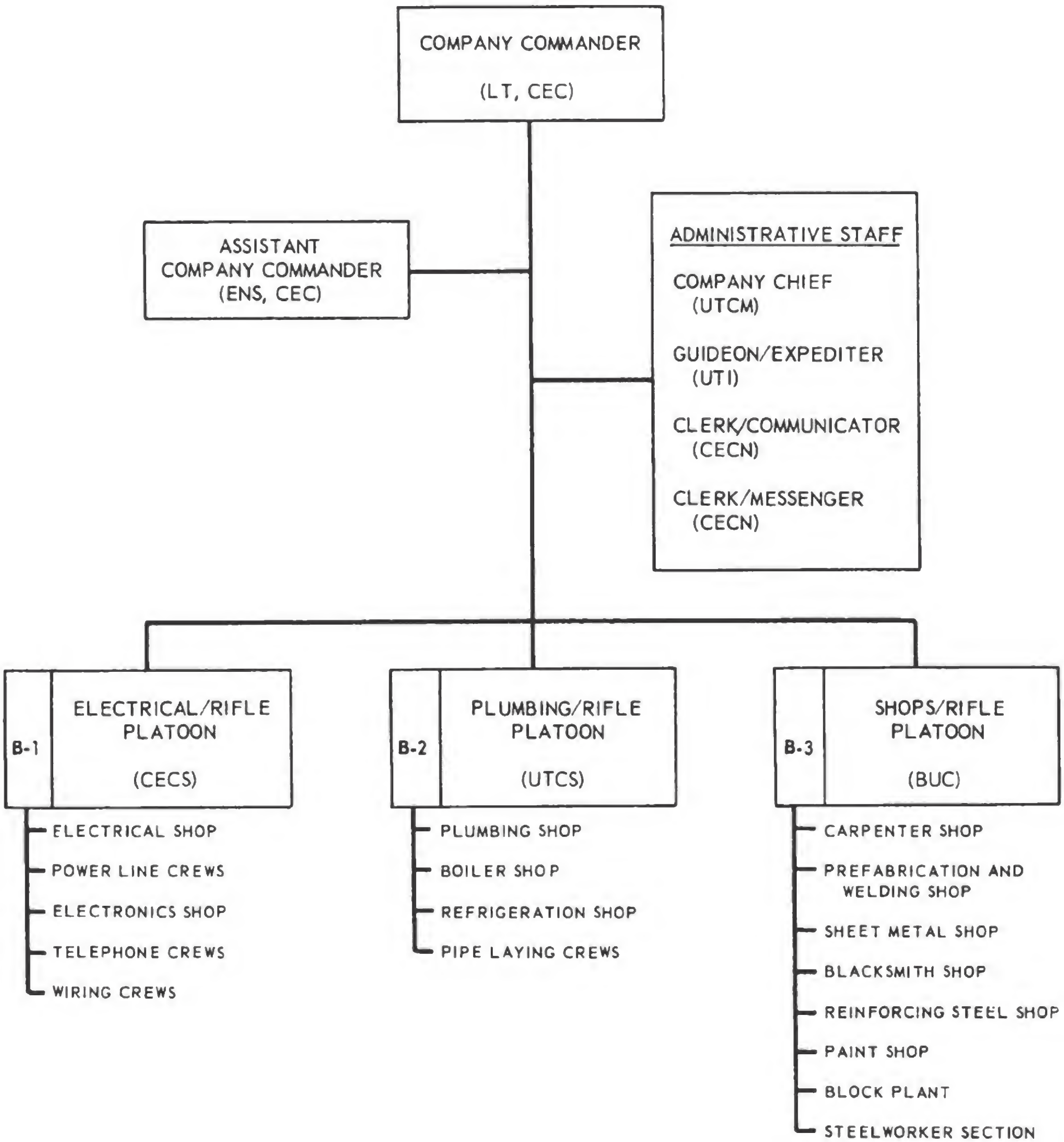
The field engineering work is usually supervised by the senior Engineering Aid. The Field Engineering Section performs such functions as the following:

1. Reconnaissance, preliminary, topographic, and location surveys.
2. Construction stakeout: line and grade.
3. Regular measurement of quantities of work in place.
4. As-built location of structures for preparation of record (as-built) drawings. An as-built drawing is one which shows a structure as it was actually built. It shows, for example, any departures which were made from the working drawings, as a result of accident or unforeseen circumstances.
5. Measurement and computation of earthwork quantities.



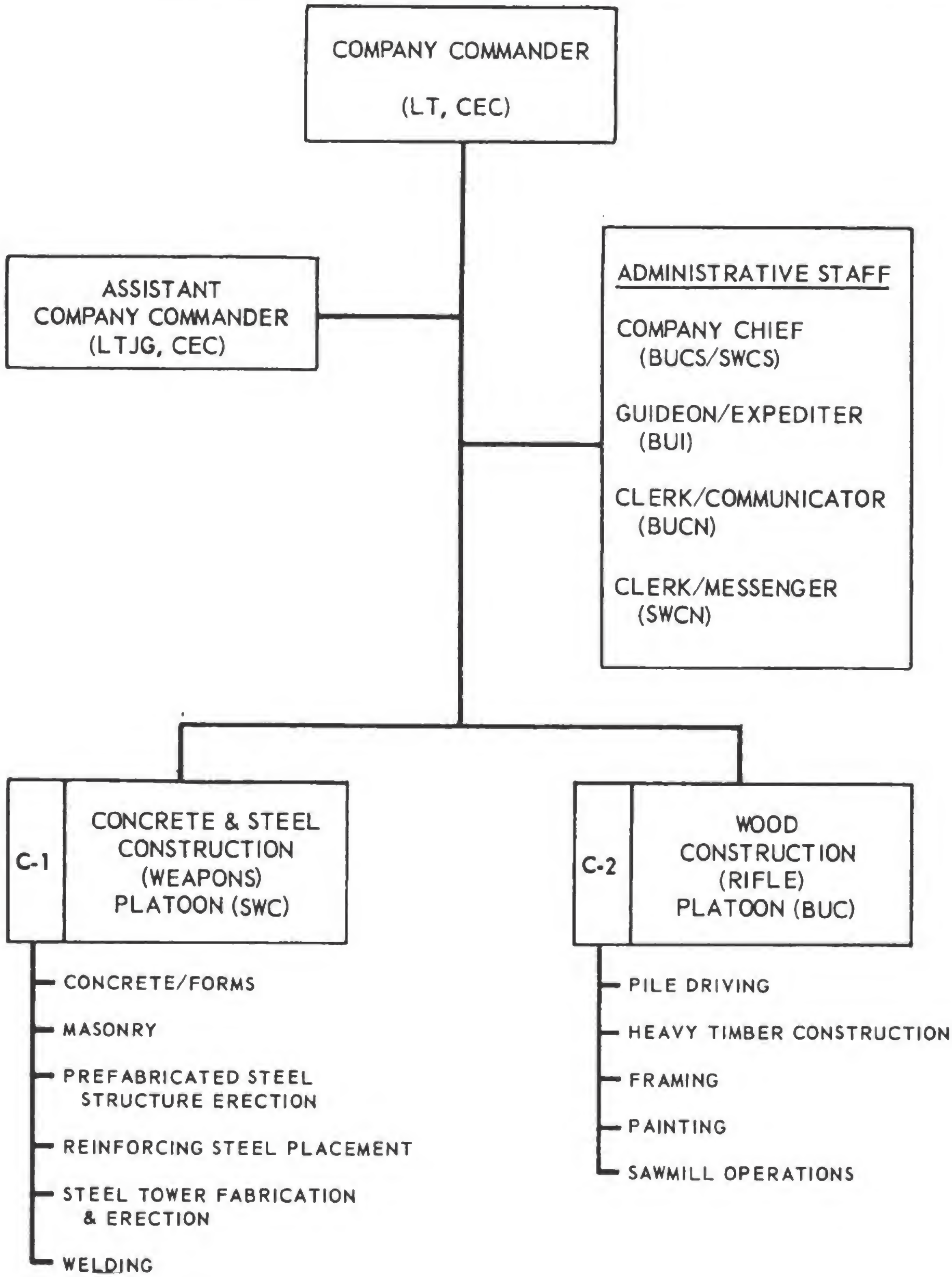
2.223

Figure 9-5.—The Basic NMCB Organization.



2.223B

Figure 9-6. — The NMCB Utilities & Shops/Rifle Company (Bravo Company).



2.223CD

Figure 9-7. — The NMCB General Construction/Rifle Companies (Charlie and Delta Companies).

6. Reduction of survey notes. This means the computation of desired values (such as bearings and distances or elevations) on the basis of notes made of measurements taken by survey parties in the field.

7. Calculations for establishing line and grade.

8. Plotting survey data.

9. Special surveys, such as property, triangulation, hydrographic, and the determination of true North.

You can see that nearly every one of these items is tied in with the work of the Builders. The necessity for constant cooperation between Builder supervisors and the Engineering Aid in charge of the Field Engineering Section becomes even more apparent.

INSPECTION AND TESTING

The Inspection and Testing Section ensures that the quality of construction work meets that specified in the specifications. In general, this requires testing of materials and inspection of structures. Concrete, for example, must be continually tested as it is mixed, to ensure that it attains the required minimum specified compressive strength. Studs, for example, must be checked repeatedly to ensure that the specified spacing O.C. is being maintained, that the studs are plumb, that corner posts are properly made, that openings are plumb and square, and so on.

With regard to inspection, it is the current concept that the men in the P & E Section will perform the necessary inspections required in addition to those conducted by project managers and supervisors. Soils, concrete, and asphalt testing will be performed by Engineering Aids specifically trained as Quality Controlmen. Other inspectors are assigned according to the needs of the work. For inspection in the various construction categories, men familiar with each category (such as Builders for structures, Utilitiesmen for utilities, Construction Electricians for electrical features, and so on) may be assigned to do the actual inspection for the section, under the Chief Inspector's supervision.

But aside from the inspection quality control maintained by the Inspection and Testing Section, a Builder supervisor must independently maintain his own quality control. It is therefore the case that a Builder exercises this important phase of his supervisory duties principally by inspection—constantly maintained—of finished work, or of work in progress. Quality control requirements are set forth graphically in the working drawings (which show, for example, stud and joist spacings, section dimensions of structural members, and the like) and in narrative form in the specifications (which tell, for example, the ingredient proportions for concrete, the maximum depth to which a joist may be notched, the joining methods required for frame, and the like).

It follows that the Builder supervisor-inspector must carry around with him, as it were, a complete knowledge of all the dimensions, proportions, and the like which are of quality-control significance. It is not easy to memorize all this; therefore, you should carry it all set down in a field notebook. The notebook should be arranged in the form of an item-by-item checkoff list, with items arranged in the order in which you will make routine inspections, and the relevant data for each item set down.

Inspectors from the Inspection and Testing Section also make soil tests as needed, and test and control all locally-produced materials, such as concrete, lumber, concrete block, crushed stone, sand, and gravel. For example, the inspectors may make tests of soil in place, take soil samples and make laboratory tests, and assist in determination and control or optimum moisture content and compaction of earthmoving operations. They measure the physical characteristics of aggregates used for concrete, such as size and gradation, moisture content, and hardness; calculate and control the proportioning of concrete mixes; and test concrete cylinders and beams.

PROGRESS CONTROL

Usually functioning directly under the Operations Officer, the Progress Control Section compiles data for progress and performance reports required by management. Such reports include MONTHLY OPERATIONS reports, MANPOWER DISTRIBUTION reports, JOB PROGRESS reports (in terms of work in place), MANPOWER AND EQUIPMENT PRODUCTION reports (that is, quantities of work in place related to man-hours and machine-hours), and PROJECT COMPLETION reports.

The Progress Control Section gets the data for these reports principally from reports submitted by project officers. A project officer gets much of the data for his reports from his supervising petty officers. Therefore, the list of reports prepared by the Progress Control

Section gives you a pretty good idea of the type of information you must gather and submit to the project officer.

PLANNING AND ESTIMATING

If the battalion has a specifically designated Planning and Estimating Officer (which it may have at the outset of an operation), the Planning and Estimating Division functions under his charge. Responsibilities of the Planning and Estimating Officer, or of an officer or petty officer acting in that capacity, are:

1. He designs structures and utilities as necessary.
2. He supervises the modification of standard drawings, such as A & E (architectural and engineering) drawings prepared under contract by civilian firms.
3. He supervises the receipt, preparation, revision, and distribution of:
   a. Original drawings and specifications
   b. Working drawings
   c. Quantity takeoffs and bills of materials
   d. Labor and equipment estimates
   e. Workload analyses
   f. MCB job orders
   g. Shop drawings
   h. As-built drawings
   i. Topographic maps and hydrographic charts
   j. Combat situation and operations charts and sketches.
4. He supervises the reproduction of drawings.
5. He submits approved bills of materials to the battalion Construction Materials Procurement Section for supply action, advising at once of any changes in plans which require supply action.
6. He organizes the Planning and Estimating Division to operate as a Combat Operations Section and as a Control Plotting Team for emergency recovery operations.
7. He prepares combat operations plans and command post exercises.
8. He assists the Operations Officer in planning the MCB camp.
9. He performs any other planning and estimating work assigned by the Operations Officer, and collateral duties assigned by the Commanding Officer.

You can see that the Planning and Estimating Division is your source of supply for working drawings.

CONSTRUCTION MATERIALS PROCUREMENT

The Construction Materials Procurement Section is usually supervised by a senior petty officer (generally a CPO) of one of the Construction ratings. The section maintains direct liaison with the Supply Department, and assists the Planning and Estimating Section when the battalion is responsible for preparing material takeoffs.

The Construction Materials Procurement Section and/or Material Liaison Officer is responsible for:

1. Preparing, logging, and following up on requisitions for building materials based on approved bills of materials.
2. Receiving construction materials and posting tickets against bills of materials.
3. Direct delivery (whenever feasible) of construction materials from ships to locations at the job sites approved by the Operations Officer and Field Superintendents.
4. Keeping posted on job progress.
5. Close coordination with field superintendents.
6. Phased delivery of construction materials to job sites.
7. Controlled issue of construction materials to authorized persons in authorized amounts.
8. Prompt notification to the Operations Officer and Supply Department of any anticipated shortages or delays.

CONSTRUCTION CREW ORGANIZATION

As a BU1 or BUC, your responsibilities will include the organizing of different crews. As you know, a crew is organized and designated as to the type and purpose of the proposed job. The first step in organizing a crew for a construction mission, or in organizing several crews, is to decide on a JOB PLAN, by determining the answers to the following questions:

1. What is the exact nature of the job?
2. What is the best way to accomplish it?
3. How many men are required?
4. What tools, materials, and equipment are required?
5. How much time is allowed?

The next step is to select, from the available men, those best qualified to serve as subsuper-

visors. You can see here how important it is for you to ascertain the professional background, technical knowledge, and supervisory capacities of every man in your unit.

To each subsupervisor you should assign men capable of performing the tasks which the subsupervisor will supervise. However, there arises here a matter which sometimes creates a problem of conflicting interests. It was previously stated in this chapter that a supervisor's first responsibility is production, and this remains unavoidably true. Consequently, you will inevitably select for (let's say) stairway layout the man who has done stairway layout before. Similarly, for all work requiring special skills, you will select men whose experience indicates that they possess these skills.

A disadvantage arises here which is more or less characteristic of the unit-assembly system of production. The man who is (for example) good at stairway layout gets into a rut in which he seldom does much of anything else—develops into a man with only a single skill, you might say. On the other hand, when you designate an inexperienced man for stairway layout, your production and quality may fall.

As a conscientious Builder supervisor, you must devise answers to this problem. Generally speaking, the answers can be found among the unskilled men designated as helpers in every group. You must see to it that stairway-layout skills (for example) are communicated to the helpers. This involves seeing to it that the stairway-layout subsupervisor, the experienced stairway-layout man, and the helper himself are informed of the problem and the solution you propose for it. The solution is one in which production is maintained while training goes on. Another phase of the solution, of course, is seeing to it that the stairway-layout man is assigned, when there is no stairway-layout work to be done, in areas in which he may acquire the other skills consistent with his rate. Also, ensure that he is kept aware of the danger of becoming a single-skill Builder.

When an order to proceed with certain work is received (usually from the project officer), the work, or part of it, should be assigned to an available crew on a WORK ASSIGNMENT SHEET like the one shown in figure 9-8. Work crews should correspond as closely as possible to the military structure, particularly in a combat zone. The crew here was a wall framing crew. On 6 February they were assigned to framing the east wall of a CPO club building. They spent that day laying out stud locations and stud patterns, and stacking lumber. On 7 February they cut and erected the corner posts, bottom plates, and 10 ft of studs. On 8 February they framed the remaining studs and the top plates. On 9 February they framed rough openings for doors and windows, and on 10 February installed bracing and fire stops.

You can see how the work assignment not only indicates where workers are assigned, but also maintains a running history of the progress of the work of each crew, and indicates the current state of completion of their phase of the work.

SAFETY SUPERVISOR

The extent to which the matter of safety must be emphasized varies with the nature—with the inherent danger, that is—of the particular activity. The extent to which construction is inherently dangerous is obvious.

The Navy spares no expense or effort to provide effective sfaety measures and equipment to protect the men. But such provisions are worthless unless they are applied where and when they are needed. Safety is never automatic; it must be deliberately practiced. It is the responsibility of the Commanding Officer and every officer and petty officer of a battalion to ensure that safety is practiced by EVERY MEMBER of the battalion EVERY DAY.

Safety is a command responsibility which requires deliberate action at every level of the chain of command. The Commanding Officer has ultimate responsibility for the safety of the battalion, but this in no way relieves officers and petty officers of their responsibilities. The mere application of prescribed safety rules and equipment is not enough. Each officer and petty officer must learn to foresee and provide against hazards in the everyday activities of his unit.

Every battalion has a formal safety organization. However, whether or not you have a specific position in this organization, as a construction supervisor you are automatically a safety supervisor.

BATTALION SAFETY ORGANIZATION

The Commanding Officer organizes the safety program of the battalion. The MCB Safety program covers six points, as follows:

WORK ASSIGNMENT WALL FRAMING CREW

START: 6 FEB. 19

CREW CHIEF: JONES, A., BU 2
LAYOUT & CUTTING: SMITH, B., BU 3
INSTALLING: { BROWN, B., CNBU
MURPHY, R., CNBU
HELPER: BAKER, R., CN

DATE	PROJECT	TYPE OF WORK	SCOPE OF ASSIGNMENT	BEGINNING OF JOB	REMARKS
6 FEB	BLD. # 20 C O CLUB	WALL FRAMING	EAST WALL	S E CORNER	LAYOUT & STACK LUMBER
7 FEB	"	"	"	"	CORNER POST, BOTTOM PLATES, & 10 FT STUDS
8 FEB	"	"	"	10 FT FROM SE CORNER	REMAINING STUDS & TOP PLATES
9 FEB	"	"	"	DOOR #1	FRAMES, DOOR #1, WINDOWS #2 & #3
10 FEB	"	"	"		DIAGONAL BRACING & FIRESTOPS

117.40
Figure 9-8.—Work assignment sheet.

1. A safety policy statement by the Commanding Officer.
2. Expert staff direction.
3. Active participation by all officers and petty officers.
4. A program of safety discipline, training, and recognition.
5. Safety inspection.
6. Accident reports and program evaluation.

The Commanding Officer appoints a Safety Council and Safety Officer to assist him in carrying out the details of implementation and supervision. The Executive Officer makes certain that all prescribed or necessary safety precautions are understood and effectively applied.

SAFETY COUNCIL

The organization and responsibilities of the Safety Council are as follows:

1. The Executive Officer presides over the MCB Safety Council. Other members of the council are the Operations Officer, Medical Officer, A-Company Commander, Safety Officer, and any other members designated by the Commanding Officer.

2. The council advises the Commanding Officer on safety matters. It meets periodically to analyze the causes of accidents and to recommend safe work practices and procedures in the battalion.

3. The Safety Officer executes the program recommended by the council and prescribed by the Commanding Officer.

SAFETY OFFICER

The duties of Safety Officer are usually assigned to the Engineering Officer. The Safety Officer has a continuing staff responsibility for all aspects of safety in the battalion.

The Safety Officer prepares a safety program for review and comment by the Safety Council and approval of the Commanding Officer. The program provides for lectures, instruction, demonstrations, movies, posters emphasizing safety precautions and practices, safety inspections, awards and ceremonies, investigation of accidents, and any other activities which will contribute to accident prevention. Company commanders, department heads, platoon leaders, and petty officers deliver most of the instructions and lectures.

The Safety Officer and his subordinates in the safety program (including Builder supervisors) keep a constant watch on procedures for handling materials, accessibility of firefighting equipment, methods of storing flammable materials, and all hazardous operations. The Safety Officer has authority to stop at once any operation or hazardous practice which may, in his opinion, cause injury to personnel or damage to materials or equipment.

SAFETY INSPECTOR

A chief petty officer is assigned as Safety Inspector to assist the Safety Officer in executing the details of the battalion safety program. The Safety Inspector should receive special indoctrination and training for this billet.

SAFETY RESPONSIBILITIES

Every man in a battalion, whether in a position of authority or not, has specific safety responsibilities. However, the responsibilities of those in positions of authority (which includes Builder supervisors) are naturally more extensive.

Responsibilities of Those in Authority

The safety of subordinates is an inherent responsibility of all persons who exercise authority over others. Each officer and petty officer must continually look for hazardous situations and eliminate such dangers to his men. Each individual in a supervisory capacity must perform the following safety functions:

He instructs each person under his charge on safety, by describing what is to be done, illustrating the safe way to do the job, and requiring the subordinate to demonstrate that he can do the job in a safe manner.

He frequently checks to ensure that crews are applying safe methods.

He corrects unsafe working conditions AT ONCE.

He prescribes safe methods for each job operation, and the use of proper tools, equipment, and safety devices.

He inspects all equipment, both before and during use, and removes unsafe equipment from service at once.

He contacts his superior in the chain of command whenever he cannot himself neutralize unsafe conditions.

He consults the Safety Officer whenever he is himself in doubt as to the safe work practices for a given job.

He arranges for prompt treatment of injured in case of accident, and in such a case notifies immediately the OOD and any other persons concerned.

As soon as possible after an accident, he completes a supervisor's report of accident on NavExos Form 108, forwarding this to the Safety Officer through channels.

If disciplinary action with regard to any person involved in an accident is called for, he puts such person on report.

MCB directives sometimes require monthly "on-the-job" safety meetings. Such meetings are usually devoted to brief discussions of the safety hazards and precautions relating to current jobs. After each meeting, a longhand memo, prepared by the senior supervisor present at the meeting, and showing the date, subject, and number of persons attending, is forwarded to the Safety Officer.

All Hands Responsibilities

Every man is responsible to himself, his family, and the Navy for the use of every available means to prevent accidents. Outright, willful violations of safety directives are, of course, serious offenses subject to disciplinary action like other acts of disobedience. However, even a negligent violation may constitute malperformance of duty and require disciplinary correction.

With regard to safety, each individual must:

Observe himself ALL safety precautions applicable to his work.

Report to his immediate superior in the chain of command any condition, equipment, or activity which he considers to be unsafe.

Warn others he believes to be endangered by known hazards or by failure to apply safety precautions.

Use protective clothing or equipment of the type approved for the safe performance of his work.

Report to his supervisor any injury or evidence of impaired health occurring in the course of the work.

Exercise reasonable caution in the event of an unforeseen hazard.

SAFETY

Safety precautions should be posted in a conspicuous place on or near any equipment, component, or material which presents a hazard to the security of the activity or to the safety of personnel. For example, precautions necessary for the safe handling, stowage, and security of dangerous materials such as ammunition, explosives, or flammables should be posted at or near the storage space designated for those materials. The Commanding Officer and others in authority may find it necessary to issue special precautions to cover local conditions and unusual circumstances.

Supervisory personnel have the responsibility of seeing that safety precautions are strictly observed in their own work areas. These supervisors are under orders from, and responsible to, the Commanding Officer.

SAFETY EQUIPMENT

Safety equipment is available to the battalion through regular allowance lists and special requests. Allowance lists provide most of the protective clothing and other safety equipment normally required.

Planning for specific missions entails consideration of the safety equipment required. Requests for more of an item on the allowance list, or for special items not on the list, must be made well in advance to allow time for procurement and delivery.

The Navy Sight Conservation Program promotes the use of protective-corrective eyewear whenever needed by Navy personnel.

The ordinary corrective lenses supplied to Navy personnel (for nearsightedness and the like) do not, of course, protect the eyes against flying particles. Protective cover goggles which will fit over ordinary glasses are available. Because the wearing of glasses and additional goggles is cumbersome, hardened-lens eyewear which combines correction and impact resistance in the same lens can be obtained. Such eyewear is provided for men who must habitually wear corrective glasses and are regularly exposed to eye hazards.

SAFETY EQUIPMENT TRAINING PROGRAM

The Safety Officer prepares and supervises a training program on the selection, use, and maintenance of safety equipment. The Safety Officer and all officers and petty officers concerned make periodic inspections of safety equipment to determine that all required regular and special items are on hand and in serviceable condition.

Users of safety equipment are also responsible for its care and serviceability. The Safety Officers of most naval shore activities maintain facilities for the repair of safety equipment. A construction battalion is authorized to utilize the services of such facilities.

MOTOR VEHICLE SAFETY

The major number of accidents in a construction battalion usually involve motor vehicles and construction equipment. Whether the number of such accidents is kept to a minimum depends largely upon the effectiveness of the safety program prescribed by the Commanding Officer. The A-Company Commander controls the operation of all motor vehicles and construction equipment. He is responsible for driver training, examination, and licensing. He is also responsible for the operation, maintenance, and inspection of vehicles and construction equipment. Therefore, he has major responsibility for developing and enforcing safe driving discipline.

Group discussions led by experienced petty officers often help drivers to "think safety." Such discussions may profitably center around the case studies of motor vehicle accidents presented in battalion accident reports.

ACCIDENT REPORTS, INVESTIGATIONS, AND RECORDS

Various accident records and reports are essential as a basis for legal, administrative, disciplinary, and corrective action relating to accidents.

MOTOR VEHICLE ACCIDENT REPORTS

Every accident involving a Navy motor vehicle or item of construction equipment must be reported by the operator on Standard Form 91, "Operator's Report of Motor Vehicle Accident." Copies of this form and a pencil should be carried in every Navy vehicle at all times. In case of an accident involving another vehicle, this report must be made, even if the driver of the other vehicle states that no claim will be filed for damages, or no matter how unfavorable the circumstances of the accident may be to the Navy. The report must also be made in the case of an accident not involving another vehicle. The operator involved in an accident must deliver the accident report, or ensure its immediate delivery, as soon as possible, to his supervisor, who must forward it to the motor accident investigating officer of the battalion.

INJURY REPORTS

Fatal and lost-time injuries must be reported on the following three forms:

An "Accident Report," NavExos Form 108, prepared by the supervisor of any man involved in a fatal or lost-time accident. This report is forwarded to the Safety Officer.

A "Report of Injury or Occupational Disease," NavExos Form 109, prepared by the Safety Officer in connection with each accident, and forwarded at the end of the month to the Safety Division, U. S. Navy Office of Industrial Relations (Code 500).

A "Quarterly Accident Data Report," NavExos Form 110, prepared by the Safety Officer at the end of the quarter and forwarded to the Safety Division, U. S. Navy Office of Industrial Relations (Code 500). This report contains a summary of the data shown on the separate reports of injury or occupational disease. It also shows the battalion's lost-time accident frequency rate and lost-time accident severity rate for the quarter. This data reflects, in general, the successfulness of the battalion's accident prevention program. It is therefore presented and discussed at meetings of the Safety Council. A comparison with previous quarterly records indicates generally whether things are improving or getting worse.

ACCIDENT INVESTIGATIONS

The Navy requires that every accident resulting in death or injury to naval personnel be officially investigated. Accidents involving motor vehicles and construction equipment are usually investigated by a motor accidents investigation officer regularly appointed by the Commanding Officer. For other accidents the Commanding Officer appoints special investigating officers and boards as required.

In all cases the principal purpose of the investigation is to determine causes and fix responsibility. The investigative report includes findings as to whether the accident occurred in or outside of the line of duty, and whether or not negligence or misconduct was involved.

As soon as the cause of an accident has been determined, every possible measure is taken to prevent a recurrence.

OFF-DUTY SAFETY

More lives, time, and property are lost because of off-duty accidents than as a result of on-the-job accidents. Therefore, the battalion safety program places heavy emphasis on all aspects of off-duty safety. Each member of the battalion must be impressed with the importance of safety off the job as well as of safety on it. Directives and advice on leave, liberty, swimming, boating, hunting, fishing, camping, on-base and off-base operation of private cars, and other activities must be carefully devised in terms of safety.

Thus safety must be practiced all the way around the clock. Each member of a battalion must constantly protect himself, his fellowmen, and the Navy against accidents, both on duty and off.

CHAPTER 10

CONSTRUCTION INSPECTOR:BUILDINGS

The Builder who is well qualified and has shown himself capable of handling responsibility may be called upon at times to serve as INSPECTOR of new construction projects. Information that will aid you in conducting inspections of new construction work is given in both this chapter and the one that follows. This chapter discusses responsibilities of the inspector, and points out items to be checked in inspecting various parts of buildings and other such structures. The next chapter deals with check points to be covered in inspecting additional types of structures, such as cofferdams, bridges, and pavements. You may also have occasion to conduct maintenance inspections of existing structures; however, information relative to the inspection of existing structures is presented in chapter 12. Bear in mind that the subject of inspections is broad in scope, so it is not intended to point out every item to be covered in making an inspection. In addition to the check points given here, other important points may need to be included in your inspection, depending upon local regulations, special requirements, and so on.

RESPONSIBILITIES OF INSPECTOR

The prime function and responsibility of the inspector is to assure that the work is performed in all respects in accordance with the drawings and specifications. These requirements are usually—but not always—sufficiently exacting to necessitate high standards of quality, both in materials and workmanship. In the case of temporary or emergency construction, quality requirements may be lowered intentionally. The inspector, therefore, must be careful to ascertain that the work is of the required quality, but he also must be equally careful not to demand a quality of work superior to that required.

In some cases the specifications for the project, or the standard specifications included therein by reference, may establish definite tolerances over or under the exact measurements that will be accepted, and the inspector then has only to verify that the work is within the specified limits. On most phases of the work, however, specific tolerances cannot be fixed, or at least are not fixed, and intelligent judgment is required in interpreting such requirements as plumb, true, level, and perfect. The intention is that workmanship shall be of the most suitable grade for the purpose. The inspector, therefore, should have a comprehensive practical knowledge of the grades of workmanship appropriate in the various classes of structures and in the various details of the work.

The degree of accuracy appropriate is dependent on many factors. Structural framing may have to be true within 1/16 inch, or in some cases within 1/8 inch. Concrete work can seldom be held closer than 1/8 inch, and in some special types of structures much larger tolerances must be permitted and allowed for.

The inspector must assure himself that the principal centerlines, column lines, and controlling overall dimensions and elevations are correct; that minor errors are not permitted to accumulate but are compensated continuously; that exposed work is visually acceptable; and that special care is taken when greater than ordinary precision for the type of work is necessary for some special reason.

It is important that the inspector make clear at the outset of the work what will be expected and make sure that the initial portions of the work fulfill these expectations. It will invariably be found that the standards of accuracy established and enforced during the first few days work will set the pattern for the rest of the work. The inspector must be consistent in the standards he exacts. He must be reasonable, but he cannot be lenient in this respect.

Inspection of temporary construction must be limited to that sufficient to assure that the work is adequate and safe for the purpose. The

inspector should, however, be alert to note any defective construction, unsound materials, possible weaknesses, and hazards and call them to the attention of his superior.

An extremely important and relatively difficult phase of inspection is in the checking of a project as it nears completion to make sure that every item required for the completion of the project has actually been provided. It is essential that a check-off system be used for this purpose and that the system adopted be initiated early enough so that ample time will be available for delivery and installation of any items overlooked. This is particularly necessary in times of emergency when long lead time between ordering and delivery is encountered for many critical items of material and equipment. The inspector must maintain strict watch over cleanup items, particularly where portions of the work may be concealed in later stages. Because of the inherent tendency of construction projects to drag out to a slow finish, the inspector will have to exert correspondingly greater pressure to obtain full and expeditious compliance with the requirements in this respect.

The inspector may be responsible for maintaining accurate and detailed records of performance of the work and of various pertinent matters. Records and reports should be in clear and complete form so that no possible misinterpretation of the facts or uncertainty as to events may arise therefrom.

The inspector has contact with other people and this calls for an understanding of human relations. He must use tact and courtesy in dealing with others. If he gives criticism, he should do so constructively and in a manner that will not cause resentment. He must avoid showing any favoritism or partiality, and particularly he must avoid making any statements or taking any action that might discredit any supervisor or foreman before his subordinates.

It is imperative that the inspector conduct himself at all times in a manner commensurate with the highly responsible position he occupies. He must be absolutely honest in his dealings with others. Integrity is a fundamental requisite. He must be trustworthy, loyal, diligent, and punctual. He must be dignified, steady, and poised in all his actions. When his job involves supervising others, the inspector must be firm but fair in handling his subordinates. He must maintain his self-respect and win the respect of all his associates, keeping in mind that a harmonious relationship is more successful than one hampered by friction and discord.

FOUNDATIONS

Various types of foundations are used for buildings. With space being limited, let us consider only two of the main types—mat foundations and spread footings.

MAT FOUNDATIONS

Mat foundations are normally used when the subsoil is not considered good enough for spread footings and when the area involved is so large that piles would contribute so little to the supporting power of the ground in comparison with their cost as to be uneconomical. Mat foundations may take the form of a hollow concrete box with intermediate walls or columns to permit taking advantage of the weight of earth removed in the excavation to offset in part the load imposed on the mat foundations. The inspector must make sure that the subgrade is carefully leveled to the specified elevation so that the concrete will be of full thickness and that special sand or gravel is spread and compacted if called for. The inspector should be alert to detect any wide variations in the quality of the subgrade. Concrete for mat foundations will usually be specified as conforming to NAVFAC Specification 13Y. In chapter 11, the section entitled "Concrete Construction" contains various factors that will apply in the inspection of mat foundations.

SPREAD FOOTINGS

Spread footings are designed for definite load per square foot, based on prior investigations of the site, or on general knowledge of the characteristics of the soil in the area. Usually the drawings indicate both the sizes of the various footings and the loading on which they are based. The inspector's primary function is simply to assure the correct size of the footings, with satisfactory concrete reinforcement, or other parts as shown or specified. The inspector should be alert, however, to detect any significant variations in the quality of the substrata from that indicated by boring records or assumed designed loadings.

Spread footings must be constructed in the dry, except when the project specifications provide otherwise. Excavations must be dewatered by pumping from sumps located outside the limits of the footing, or by well pointing. In such cases, the inspector must make sure that the surface of the subgrade on which the footing is built is not unduly softened and weakened

by the presence of an excess of moisture. If such conditions exist, he must see that the unsuitable material is removed and replaced with satisfactory material as specified for such conditions. If the specifications do not cover this case, replacement with lean concrete should be required.

Heavy foundations frequently require the provision of a steel grillage to distribute the concentrated load of the column. Such grillages will be required either under spread footings, or more frequently, under footings supported by piles, caissons, or other deep supports. When grillages are required by the drawings and specifications, the inspector must make sure that they are carefully fabricated, adequately painted or coated as specified, truly located, aligned and leveled, provided with all necessary anchor bolts in true vertical position, and bedded firmly and thoroughly in the footing.

It is essential that anchor bolts be set with the utmost accuracy in respect to both position and level. Errors discovered after the concrete has set are extremely expensive to correct. This is particularly vital when sleeves are not specified or permitted to allow for lateral play. Anchor bolts are usually set to a template, which is carefully aligned with the building lines and leveled to a definite elevation. The inspector must check the setting and verify beyond question that it is accurate within permissible tolerances before permitting concreting to proceed. The templates should be checked periodically during the course of the work to make sure that they have not been disturbed. Particular attention must be paid to the bolt settings to make certain that there is sufficient thread exposed above the top of the steel base plate to permit full engagement of the nuts without excessive projection of the threaded bolt. The inspector must also make sure that the anchor bolts are provided with hooks, L-bends, swaging, or other anchorage devices as shown or specified. When sleeves are specified, the inspector should make sure that the bolts are centrally located in the sleeves to provide leeway in adjustment in all directions. He must ensure that the sleeves are NOT installed in such manner as to decrease the holding power of the bolts. Care must also be taken later to make sure that the sleeves are properly filled with grout, lead, or sulfur, as the specifications may require, after the steel has been erected and aligned.

Concrete for footings will usually be specified as conforming to NAVFAC Specification 13Y. In chapter 11, the section on "Concrete Construction" contains various factors that will apply in the inspection of concrete for spread footings, as well as mat foundations.

Care must be taken to ensure that all wood and debris are removed from around the footings, that clean earth free from objectionable material is used for BACKFILL, and that this fill is thoroughly compacted to substantially the same density as the surrounding undisturbed earth. This is particularly important when pavement or floors are to be built adjacent to the footing, to avoid differential settlement.

FRAMING

Several types of framing are used in construction work. Our discussion here is limited to three common types of framing: steel, concrete, and wood.

STEEL FRAMING

Steel framing is used principally on shop buildings requiring relatively long-span construction and on multistory buildings for comparatively light occupancy. In most cases factory inspection of material, fabrication, and shop assembly will have been made. The inspector must make certain that the steelwork as delivered is correctly identified, sorted, handled, and stored.

On building construction, the inspector must give special attention to the alignment and leveling of steel. He must make sure that columns are plumb, that girts are aligned in true planes, and that beams and girders are level and set at the prescribed distance below finished floor or roof elevations. He must assure that all steel is held and adequately braced by guy cables until it is riveted or welded. Special care must be taken with roof trusses, which may be inherently unstable until all bracing and purlins are in place. The inspector must be certain that adequate erection bolts are used to hold all joining surfaces tightly together at joints and to hold the assembled steel in alignment. He also must make sure that mismatched holes are drilled or reamed and not drifted.

On WELDED work the inspector must make sure that suitable electrodes are used, as speci-

fied; that all base metal at welds is cleaned, brought into correct position, and clamped or backed up as necessary; that welds are made in the approved sequence to minimize internal stresses and distortion; that welds are of satisfactory quality, length, and size; and that the parent metal is not damaged. On truss joints the inspector must be certain that lengths of welds are proportioned as indicated so that eccentricity of the welded joint to the line of stress is avoided. The inspector should require that all loose slag be removed. Special care must be taken to make sure that welds made overhead or in awkward or restricted positions are sound and full.

The inspector must assure that the shop coat and welds are touched up as specified and that the specified number of coats or field PAINT is applied. He must make sure that paint is of the type, quality, and color specified.

CONCRETE FRAMING

Concrete framing for buildings generally consists of columns, girders, beams, and slabs. Flat-slab construction consists of columns, capitals, plinths, and slabs, with girders and beams used only to frame around openings and to support spandrel walls. Metal pan construction may also be used for floors. Increased use may be made of prestressed concrete construction in the future.

On building construction, the inspector must assure that all wall ties, anchors, inserts, and other appliances for fastening appurtenances are installed in the forms in the exact locations needed and that all openings for pipes, ducts, vents, and other purposes are formed in the correct locations. A thorough check must be made, before permission is given to start concreting, to assure that no item has been overlooked.

Special attention must be paid on building work to the accuracy of alignment, trueness of exposed surfaces, and finish. The inspector must assure that change of floor levels caused by shrinkage of columns is fully compensated. He must give close attention to location of construction joints and of expansion joints, if required, and be certain that the latter are extended through the structure and provide the clear opening indicated. He must make sure that slab forms are kept in position for the full period specified and that forms under beam and girder soffits are kept in place for the additional period required. He must make certain that all concrete is cured in the proper manner and for the full period prescribed.

WOOD FRAMING

Wood framing is widely used, particularly for emergency and temporary constructior.. Quarters and temporary barracks may be of typical frame-house construction. Storehouses, particularly of the large one-story type, may have frames of wood posts, beams, and joists, with wood roof sheathing. Shop buildings may have to be built of wood when steel and concrete are not available. Such structures may require heavy built-up timber columns and trusses, particularly if crane runways have to be provided. Large wooden hangars have been built, necessitating trusses, with each member consisting of a number of heavy planks. Drill halls and similar structures requiring wide-span construction have occasionally been framed with laminated wood arches consisting of a large number of plies of relatively thin planks glued together with a special waterproof and durable glue. Many other special types of framing may be encountered, such as slow-burning mill construction, lamella roof arches, and rigid frames.

The inspector must familiarize himself fully with the drawings and specifications and the standard specifications referenced therein. He must make sure that framing of the type shown or specified is provided and that all wood is of the species, grade, size, and surfacing specified and has been inspected and grade marked.

The inspector must make certain that nails, bolts, screws, connector rings, and other fastenings conform to requirements in type and size. He must ensure that metal ties, straps, hangers, stirrups, joist hangers, and similar accessories are suitable and correctly used. Where numerous plies of lumber are held together by long through bolts, the inspector should recheck the tightness of the nuts before the project is finally accepted because shrinkage of the lumber may cause them to loosen.

WALLS

Walls are made of a wide variety of materials, so detailed information on wall construction

cannot be given here. With space being limited, only three types of wall will be discussed here; they are block walls, stucco walls, and wood walls.

BLOCK

Concrete blocks, also called concrete masonry units, are made with stone, gravel, shale, slag, or cinders as the coarse aggregate. Units usually are made with nominal widths of 3, 4, 6, 8, 10, or 12 inches. Walls and webs usually are 2 inches in nominal thickness, but actual thicknesses may run 1/4 to 3/8 inch less. Units are made with 2, 3, 4, and 6 cores. They are also manufactured in half units and in special units, such as jamb blocks, end blocks, headers, and double corner units.

In construction involving the use of concrete block, the inspector must check all material for damage, imperfections, stains, color, size, and marking. He must make certain that only material conforming fully with requirements is used in the work. He should verify the course heights, bond, color pattern, and similar basic requirements.

The inspector must make sure that all masonry units are carefully handled at all stages of the work, to preclude damage, and that scaffolds and floors are not overloaded by stacking them too heavily.

The inspector must determine that joints conform to the specifications in materials, type, pointing, and finish. To assure sound watertight construction, he must make sure that each joint is completely filled for its entire length and depth, is free from voids, and is correctly struck without excessive troweling. He must make sure that the horizontal joints are truly level and that the vertical joints are broken, staggered, or patterned as prescribed or shown.

The inspector must determine that all joints are tooled to the prescribed form, if so specified. Where pointing is prescribed, the inspector must assure that the mortar joints are raked out to the specified depth, saturated with clean water, refilled solidly with mortar, and tooled. He must require that all surplus mortar and stains be removed as the work progresses. He should assure that horizontal or bed joints are finished first and then the vertical joints.

The inspector should make sure that exposed surfaces of masonry units are washed with water and brushed with a stiff brush until all mortar stains have been removed. A weak solution of muriatic acid may be used for stubborn stains, but care should be exercised to require copious flushing with clean water. Finished terra cotta facing should be cleaned with a stiff brush, using soap powder boiled in water. The brushing should be continued until all stains and dirt are removed. The facing should then be rinsed thoroughly with clean water. The inspector should not permit the use of wire brushes, abrasives, or metal tools because they may damage the surface, color, edges, and joints.

STUCCO

Stucco usually is specified as composed of portland cement, hydrated lime, sand and water and may have integral waterproofing or coloring pigment added. Painted or galvanized metal lath, expanded metal, or wire mesh is used for the support of stucco, except on masonry walls, and requires nails, staples, and tie wire for fastenings. The inspector must make certain that all material conforms to the requirements of the project specifications and the referenced standard specifications.

Stucco may be applied on masonry, concrete, or wood frame walls. The inspector must make sure that the masonry has an unglazed rough surface with joints struck flush and adequate key to assure good bond. Concrete is often given a "dash" coat of neat cement and sand before the stucco is applied. If the base is wood frame walls, the inspector must determine that the lath or wire is securely fastened to the framing and tied together to form a taut, strong support to the stucco. Specifications usually will require application in three coats: scratch, brown, and finish.

The inspector must make sure that all masonry joints are filled, struck smooth, and allowed to set prior to applying the SCRATCH COAT. He must make certain that the SCRATCH COAT is pressed thoroughly into the joints of the masonry or into the openings of metal or wire lath to assure adequate key and bond. He must determine that this coat is applied carefully to level and plumb irregularities, that it is scored or combed after completion to provide good bond, and that it is permitted to dry for the specified period.

The BROWN COAT is usually of the same composition as the scratch coat. The inspector must make sure that the scratch coat is wetted immediately before the brown coat is started; that the brown coat is applied, rodded, and floated to bring all surfaces to true flat plumb planes;

that the surface is combed by fine cross-hatching to provide a bond for the finish coat; and that the coat is permitted to dry for the prescribed period.

The FINAL COAT, also called the finish coat, is a relatively thin coat of special composition to provide the finished surface, texture, and color. The inspector must make sure that this coat conforms to the specifications in composition, including colored aggregate, pigment, and integral waterproofing, if prescribed; that it is carefully applied to assure true plane or curved surfaces and sharp edges; and that on completion it is protected from excessive heat and kept moistened for the specified period to preclude hair cracks, crazing, and checking.

The inspector must make sure that all surfaces are true; that the surface texture conforms to the finish specified and to the approved sample, if any; and that the color is of a permanent type, is thoroughly incorporated in the finish coat, and matches, after the stucco is dry, the color specified or indicated by a previously approved sample.

WOOD

Wood walls are used for quarters and for temporary or emergency-type construction of barracks, messhalls, and other buildings. Siding used is of a wide variety of patterns, such as clapboards, drop siding, shiplap, bevel, or tongue-and-groove. Board and batten construction is used either for emergency construction or for architectural effect on quarters, the boards being installed vertically, with the battens covering the joints. Shingles are used occasionally.

The inspector must make sure that the wall material conforms to the specifications as to the kind of wood, grade, and manufacture or has been inspected or grade marked. He must assure that wall sheathing is tight, covered with building or sheathing paper, and flashed as necessary for weathertightness. He must make certain that siding is applied carefully so that lines are straight and true and that laps and exposed faces are correct. Also, he must make sure that nails are of the specified kind and weight, are driven flush, recessed, or blind as prescribed and that, if recessed, they are filled over with a suitable plastic wood putty.

On board and batten construction, the inspector must make sure that boards are set tightly together, with joints truly vertical; that battens are truly vertical and truly centered over the joints; and that both boards and battens are securely nailed as prescribed. At corners, he should ensure that the board on one side laps over the end of the board on the other side and that two battens are used, each covering the previous joint.

On shingled walls the inspector must determine that shingles are of the correct length and butt thickness; that starter courses are correctly set on drips, or doubled, as specified; that all horizontal lines are true; that shingle exposure is as shown or specified; that shingles are laid with tight or slightly open joints as prescribed; that shingles are nailed above the butt line of the next course above with the prescribed number of nails of specified material, type, and weight; that all flashings and valley gutters required are correctly installed; and that ridge and hip cover shingles are placed and nailed securely as shown.

WOOD ROOFS

You may have occasion to inspect various types of roof, including concrete, corrugated metal, wood, and so on. In a chapter so broad in scope as this one, we will not attempt coverage on all the different types of roof. The subject will be limited, therefore, to one type—wood roofs.

The inspector must make sure that all lumber for wood roofs has been factory inspected, association inspected, or grade marked. If not, he must determine that all lumber is of the kind, size, grade, and manufacture specified.

When inspecting the pitched roof, the inspector must be certain that all framing is cut accurately to exact length and beveled or mitered as necessary to assure full even bearing for the entire length of the cut at all meeting faces and is correctly and securely nailed. He must make sure that all bracing, trussing, collar beams, and king posts are provided as shown or specified and are securely nailed or bolted with steel straps or wood splice plates or collars as detailed.

When inspecting the flat roof, the inspector must be sure that the roof is constructed flat or sloped to drain, as prescribed. The inspector must be sure that rafters are cross-bridged in the manner and at the intervals shown or specified. He must ascertain that rafters extending into masonry walls with parapets are bevel cut, so that the end is flush with the wall at the top of the rafter and provides full bearing at the bottom of the rafter.

The inspector must make certain that SHEATHING is laid tight and straight and is thoroughly nailed as prescribed. He should be sure that sheathing on pitched roofs is started at the eaves, with the boards laid horizontally, that tongue-and-groove sheathing is laid with the tongue up, and that shiplap sheathing is laid with the lower tongue lapping the tongue of the board below and the upper tongue against the rafters to minimize leakage. If plywood sheathing is specified or permitted, the inspector must determine that the material conforms to requirements, particularly with respect to the waterproof glue. Plywood should be laid with the face grain perpendicular to the rafters, and with horizontal joints staggered at midsheet intervals and supported on headers cut in between rafters. The inspector must make sure that plywood is applied as shown or specified and is nailed at each bearing with closely spaced nails.

ROOFING

A number of different types of roofing are used on structures. One of the main types found on Navy-built structures is BUILT-UP ROOFING. It is with this type that we are concerned in this discussion.

Built-up roofing, as the name implies, is a membrane built up on the job from alternate layers of bitumen-saturated felt and bitumen. Because each roof is custom made, the importance of good workmanship cannot be overemphasized.

In inspecting built-up roofing the inspector should verify the particular combination of plies, felt, binder, and cover prescribed by the project specifications.

The inspector must be sure that the felt conforms to requirements in kind, grade, weight, and other specified characteristics and that the material as used is not crushed, torn, or otherwise damaged.

The inspector must ensure that the primer and binder furnished are asphalt or tar as prescribed. He must, also, see that the material conforms to the specification requirements for the prescribed type and is kept free from water, oil, and dirt.

The standard specifications limit the material used for surfacing to gravel or slag. The project specifications may permit or prescribe a special material such as white marble chips. The inspector must verify the types of material prescribed or permitted and assure that the material furnished conforms and is of suitable size, gradation, and cleanliness. No surfacing is required for roofing using asbestos felt.

Where a wood roof is concerned, the inspector must make sure that the roof deck has been prepared suitably to receive the roofing before permitting laying of the roofing to be started. He must ascertain that all large cracks and knotholes have been covered with tin nailed in place and make sure the roof is suitably smooth, clean, and dry. He must be certain that felt or metal valley lining is installed in all valleys, as prescribed for the type of roofing being used. He must be sure that the roof is covered with a layer of unimpregnated felt or resin-sized building paper and then covered with two layers of saturated felt, all lapped, nailed, mopped, and turned up or cut off at junctions with vertical surfaces as prescribed.

Where concrete, poured gypsum, and similar roofs are concerned, the inspector must ensure that all cracks, voids, and rough spots are filled level and smooth with grout and are thoroughly dry; that all sharp or rough edges are smoothed; that all loose mortar and concrete are removed; and that the surface is broom clean. He must be sure that felt or metal valley lining is installed in all valleys, as prescribed for the type of roofing being used. He must determine that the roof is covered with a primer of hot pitch or asphalt and then covered with two layers of saturated felt, all lapped, mopped, and turned up or cut off at junctions with vertical surfaces as prescribed. On precast gypsum or nailable concrete roofs, the specifications may prescribe that these first two plies be nailed.

With all roofs, the inspector must be certain that additional layers of binder and felt are applied as required by the specifications. He must make sure that each lap and layer are mopped full width with the prescribed quantity of hot binder, without gaps, so that felt nowhere touches felt; that the binder is applied at a temperature within the specified range and that no burnt tar or asphalt is used; and that these layers are turned up as prescribed. He must be sure that the entire finished surface is uniformly coated with binder poured on at the prescribed rate and then covered with the prescribed quantity and kind of covering material. The inspector must make sure that all roofing is free from wrinkles, air or water bubbles, and similar irregularities and that all plies are firmly cemented together.

FLOORS

You will find various types of floors in Navy structures. Two common types frequently installed, and which you may have to inspect, are concrete floors and wood floors.

CONCRETE

Concrete floors may be built on the ground at grade or on fill over membrane waterproofing. Structural concrete floors may be of flat-slab, beam and slab, beam and girder, or metal-pan type.

On floor construction the inspector must be sure that forms and supports are designed and installed so that they are readily adjusted to exact grade. He must ensure that slab forms and beam and girder side forms can be removed after the prescribed curing period without disturbing the forms under the soffits of beams and girders or these form supports. The inspector should never permit removal of soffit forms and supports and reshoring in advance of the time specified. He must make certain that all forms are accurately and adequately constructed, are adjusted to exact grade, are lined with absorptive lining if prescribed, and are oiled or otherwise treated as prescribed. Special care must be taken to secure clean true surfaces with straight arrises and uniform chamfers if the underside of the structural floor will be exposed in the finished work. The inspector must check the work to make sure that all inserts, hangers, anchors, sleeves, and other fittings are provided as required and are accurately located.

An inspection should cover the requirements for inspection of placing of concrete, which are given in chapter 11 in the section on "Concrete Construction." In addition, special care must be taken with concrete floors on grade for frame superstructures to concrete floors on grade for frame superstructures to assure that termiteproof construction is obtained. Usually this protection consists of a two-ply membrane waterproofing, laid on a course of pea gravel to break capillary action. The inspector must make sure that this membrane is completely continuous, is thoroughly sealed whenever pipes or conduits pass through the floor, and is extended into the exterior walls and finished as shown or specified.

The inspector must be sure that curing is performed as prescribed in the appropriate NavFac specification or in the project specifications. He should see that forms and form supports are left in place for the minimum length of time prescribed, respectively, for slabs, beam and girder sides, and beam and girder soffits. In addition, the inspector must note particularly any concrete that may have been frozen and report the circumstances and conditions to the proper authority.

WOOD

Wood floors for buildings of frame construction usually consist of finished flooring laid on subflooring that is supported on floor joists. Wood floors for slow-burning or mill construction usually consist of planks surfaced four sides, laid on edge with tight joints, and supported on floor beams of dimension timber spaced at fairly long spans.

The inspector must make sure that all lumber has been factory inspected, association grade marked, or otherwise inspected satisfactorily before delivery. If not, he must make sure that lumber is of the kind, grade, and manufacture prescribed and require removal of all unsuitable material. He must be sure that all beams are truly cut and have full square bearing over supports, with bolsters as shown. He must determine that the flooring is installed on edge, driven tightly together, and nailed together and fastened to the beams as indicated. He should be sure that butt joints are staggered if, and as, specified. After the floor is installed, he must make certain that it is planed and sanded to a level, even surface.

The inspector must be sure that floor joists are of correct size and overall length, are sound and free from excessive warp, and are installed bearing on sills or beams or supported therefrom by strap hangers, as shown. He must make sure that joists are braced with cross bridging and/or with solid bridging as prescribed. He must ensure that the tops of floor joists are brought to a true level plane; that subflooring of the specified kind, grade, and size is installed, made tight, and thoroughly nailed; and that building paper is laid if and as prescribed.

Wood floors are frequently installed on steel framing, particularly in light industrial buildings where steel bar joists are used. In some cases, floor joists are installed on the steelwork and the wood floor construction is otherwise the same as for frame construction. In other cases, floor decking consisting of heavy planking with square, shiplap, or tongue-and-groove joints is laid, driven tight, and bolted directly to the

steelwork with carriage bolts. The inspector must make sure that all materials and workmanship conform to the requirements of the specifications and that the floor is finished smooth and even.

PARTITIONS

Partitions are required in many structures and should be carefully checked by the inspector. A variety of materials are used in the construction of partitions, including block, tile, and wood; it is with these materials that we are concerned in this discussion.

BLOCK AND TILE

In regards to block and tile, you can expect to encounter partitions made of hollow tile, gypsum block, concrete block, and glazed tile. You should be familiar with each type material and requirements for inspecting the installation of each type.

Hollow Tile

Hollow tile partitions are usually nonload-bearing and may be laid up with webs vertical or horizontal. The specifications will usually prescribe which method is to be used. Installations with webs vertical provide somewhat greater strength, whereas those with webs horizontal provide for full mortar beds and somewhat easier laying. Partitions vary from 3 to 12 inches in thickness, depending on the unsupported height and class of construction. They are laid up with tile having scored or smooth faces, depending on whether the tile is to be plastered or otherwise concealed, or is to be left with one or both faces exposed. Scored tile may occasionally be permitted for exposed work on basement partitions.

Hollow tile is made from burnt clay or shale and is available in two types, load-bearing and nonload-bearing, and in a number of arrangements of cells. The inspector must make sure that the tile furnished conforms to the project specifications and to the standard specifications referenced therein. He must see that cracked, broken, underburnt, or otherwise defective or damaged tiles are not used. He must also be sure that scored or smooth tile is used in the various locations as prescribed.

In regards to the INSTALLATION of hollow tile partitions, the inspector must be sure that partition lines are accurately marked out on floors and carefully checked for dimensions and squareness of corners before laying of tile is started. He must assure that dowels or anchors are set in the floor at suitable intervals to come at the joints of the first course, if prescribed. He must make certain that mortar of the specified mix and correct consistency is used; that the tiles are laid up in level courses, with vertical joints staggered; that the wall as built is plumb, true, and free from wind; and that anchors or expansion devices are installed at the ends and at the juncture with the ceiling. If specified, he must be sure that expansion joint material or other compressible layer is installed between the top of the partition and the floor slab above to preclude imposition of excessive load by the deflection or settlement of the floor above. He must make certain that all joints are slushed full of mortar. If the faces are to be left exposed, he must be sure that all joints are neatly tooled and that all faces are cleaned of mortar and other objectionable matter.

Gypsum Blocks

Gypsum blocks are widely used for partitions, particularly where relatively light and easily removable partitions are required. They are furnished in blocks of large size and from 3 to 8 inches in width, and usually have a series of circular holes parallel to the short dimension.

The inspector must make sure that the block conforms to the project specifications or to the standard specifications referenced therein; that damaged blocks are not used; and that mortar, usually gypsum or plaster of paris, is prepared and used as prescribed.

Requirements for inspecting the installation of gypsum block partitions are similar to those described above for hollow tile partitions.

Concrete Block

Concrete blocks are used extensively for partitions, particularly in areas where other types are not produced locally and are not competitive in price because of freight costs. They are made with stone or gravel, cinder, slag, or lightweight aggregates, in various sizes and in a number of cell arrangements and wall thicknesses.

The inspector must be certain that block, mortar, and hardware conform to the project specifications or to the standard specifications referenced therein, and that blocks are sound

and undamaged when used. If blocks are to be left exposed, he must be sure that the surface texture is uniform and of suitable character and color.

Requirements for inspecting the installation of concrete block partitions are similar to those described earlier for hollow tile partitions.

Glazed Tile

Glazed tile is used for partitions and for interior facing of walls where a hard, impervious, glossy surface is needed for sanitary purposes, ease of cleaning, or decorative effect. There are several distinct types of tile used for these purposes, such as ceramic tile, architectural tile, and salt-glazed tile. The latter is the type usually prescribed. Tile is furnished with one face glazed or with both faces glazed. The latter is used for thin partitions, usually of low height.

The inspector must make sure that the tile conforms fully to the specifications in kind, type, quality, size, surface finish, color, and texture; that the glaze is uniform over the entire face and around the edges of the face and does not show evidence of incipient popping or crazing; and that the tiles used are free from all defects that adversely affect their durability or appearance. A semiglazed matte finish is usually prescribed. Frequently tile used must conform to approved samples. In such cases the inspector must compare the tiles delivered with the approved sample and make sure that they conform to it within permissible tolerances in characteristics. Mortar made of white sand and white nonstaining cement usually will be required. The inspector must be sure that the mortar conforms to the special requirements for cement, sand, mix, color, and consistency when used.

In regards to installation, the inspector must assure that block or tile backings for partitions surfaced with glazed tile are constructed several courses in advance of setting of tile and make sure that tiles are thoroughly bonded to the backing. If both sides of a thin partition are to be finished with glazed tile, tile surfaced and glazed on one side only is used, of two different thicknesses to make up the specified total thickness and provide bond. In thinner partitions a single thickness of tile surfaced on both sides is used. In such cases the inspector must determine whether one face is the more important and should be set true and plane, allowing all irregularities in tile thickness to appear on the other face, or whether tile should be set centrally with irregularities in thickness divided equally between the faces. His superior should be consulted if necessary. Subject to the foregoing exception, the inspector should make sure that all glazed tiles are set visually true with horizontal joints level; vertical joints staggered or patterned as shown or prescribed; and surfaces plumb, plane, and free from apparent irregularities. If tiles vary slightly in color, the inspector should be certain that the various shades are distributed to give a uniformly varying tone without patches of darker or lighter shades. He must determine that all joints are carefully filled and tooled as prescribed. He must also ensure that all exposed surfaces are carefully and thoroughly cleaned with nonabrasive detergent or soap and warm water and are thoroughly rinsed.

WOOD

Wood partitions are used in all frame construction and in many instances in structures of more permanent type. In most cases wood partitions are composed of 2- by 4-inch wood studs with sills and plates of the same material. Studs are doubled at openings, and plates are usually doubled to provide strong splices. Headers are required at heads of doors and at heads and sills of sash. Wood partitions to be finished on both sides are covered with wood lath, metal lath, plaster board, or other base, or may be covered in dry-wall construction with wall boards of various types. Wood partitions in offices are frequently of panel construction with studs spaced fairly widely apart and tongue-and-groove panels, wall board, masonite, or other material set in between the studs so the latter are exposed with equal reveal on both faces. Such partitions frequently extend only part way to the ceiling, and upper panels may be glazed. In the tropics, partitions may be surfaced on one side only, leaving the studding fully exposed on the other side to eliminate all concealed spaces and permit effective control of termites and other vermin.

The inspector must be sure that lumber is of the kind, grade, and size specified. If studding is to be exposed, he must be sure that all studs are free from bend, warp, or twist. He must determine that all panels and trim are well manufactured in accordance with the details shown and that surface covering is of the type and quality specified.

The inspector must be sure that all partitions are adequately anchored to the floor, walls, and ceiling as prescribed and, if of part height, are adequately braced and stiffened at all splices

and corners. He must be sure that studs are set truly plumb and in line, well nailed to sills and plates, and that plaster base or other surfacing or panels and trim are carefully and accurately installed so that a neat, workmanlike finish is obtained. When necessary, he must make sure that all fastenings are completely concealed behind the trim and that the latter is nailed with finishing brads.

FINISHES

The inspection of finishes for floors, walls and partitions, and ceilings is an important phase of the inspector's job. Ensure that each finishing job is properly done and gives a neat, attractive appearance.

FLOORS

Various types of finishes are used for floors. Here we will cover three of the main types: concrete, wood, and tile.

Concrete

Concrete floor finishes may be either integral with or placed separately from the structural slab and may have coloring pigment or hardening agents incorporated. They usually are specified to be in accordance with NavFac Specification 13Y. The inspector must be sure that materials and workmanship conform to the requirements specified therein for the type prescribed in the project specifications. He must make sure that color pigment or integral hardener is added in accordance with the specifications or approved manufacturer's instructions.

If the finish is to be placed integrally, he must make sure that it is applied within the prescribed time limit and to this end must ascertain that the number of qualified finishers is adequate to keep pace with the rate of placing of the floor slab or that this rate is decreased.

If separate finish is prescribed, he must make sure that the surface of the slab is well roughened, thoroughly cleaned of all loose material, and brushed with neat cement grout immediately before the finish is placed. He must be sure that the finishing concrete is placed at the driest practicable consistency to minimize shrinkage; that dusting on of cement to absorb excess water is not permitted; and that the surface is floated to a true even surface, level or slightly pitched as specified, and is troweled smooth without voids, exposed aggregate, or other visual defects. He must be sure, however, that troweling is not continued to excess, as checking, crazing, and excessive dusting of the finished floor may be caused.

The inspector must assure that the surface is cured as prescribed and for the time specified. He must also ensure that surface-hardening treatments, if prescribed, are applied after the surface is thoroughly cured, using approved chemicals of the type and in the amounts prescribed.

Wood

High-grade wood flooring is generally of oak. Maple is used for special applications, such as mold lofts or dance floors, for which a tight-grained, nonsplintering hardwood finish is required. Southern yellow pine, Douglas fir, and similar softwoods are used for wood flooring of lower grade. Flooring may be rift or edge grain or flat grain and is usually specified to be side and end matched. Wood flooring is also available in parquet or block form of solid or laminated section for cementing in place on structural floors, usually over cork or fiber insulating board.

The inspector must be sure that the flooring has been factory inspected or grade marked, or is of the kind, type, grain, grade, and manufacture specified.

The inspector must be sure that the subfloor, if any has been laid, is truly and fully supported at all points, nailed securely, and covered with building paper if prescribed. He must be certain that the flooring is laid with straight joints, that butts are staggered as prescribed, and that strips are driven tight and blind nailed. If finished flooring is laid directly on joists without subfloor, he should determine that butts are located over supports. He must assure that a minimum of very short lengths are used. If wood flooring blocks are used, he must make certain that the structural floor is absolutely level, or is made level by mastic or other means as may be prescribed; that the insulation prescribed is applied with tight joints and is thoroughly cemented to the deck; and that flooring blocks are laid in true alignment and pattern, driven up tight, and cemented in place with the specified mastic or other cementing agent.

The inspector must determine that flooring is finished by planing, coarse and fine sanding, application of liquid or paste wood filler, and

treating with wax, shellac, or varnish, or combinations thereof as may be specified.

Tile

Floor tiles are of several varieties, such as flint tile, unglazed or semiglazed ceramic tile, or quarry tile. Glazed ceramic tile, such as is generally used for wall finish, is occasionally used. Flint and ceramic tiles are usually of small size and of hexagonal, square, or rectangular shape and are delivered assembled in patterns in panels about 12 inches square, cemented on the face to paper. These tiles are also available in various squares and rectangular sizes and in a variety of colors, shades, and textures.

The inspector must assure that tiles for both field and borders are of the kind, size, color, texture, and pattern prescribed, and that adequate quantities are on hand to assure completion of each room or area. He must determine that mortar for beds and wire mesh or other reinforcement, if required, conform to the specifications.

The inspector must be sure that the structural floor is prepared ready to receive the tile and to assure a true, level, finished floor. If the floor is of wood, he must make certain that floor joists are leveled at the top and that the subfloor is set down as necessary to provide an adequate mortar bed. If the floor slab is of concrete, he must make sure that it is depressed below finished floor grade as required, roughened to provide bond, thoroughly cleaned, and wet down immediately before the mortar bed is placed. He must be sure that the mortar bed is placed and screeded and that tiles are set immediately and tamped level and true with straight, even, uniform joints. He must assure that tile placed as paperbacked panels is set so that the pattern repeats truly and so that joints between panels match those established within the panels. He must be particularly careful to determine that tile is laid parallel to the principal walls and that all special work required to fill in corners and irregular areas is placed so that joints are true and the pattern is faithfully reproduced without offset or other error. He must be sure that all joints are carefully and neatly filled with mortar as specified and that the floor is cleaned of all mortar. After the mortar has set, he should check the floor for loose tile, irregularities, or other defects and require their correction. Quarry tile may be specified to be set in bituminous mastic or in colored white cement mortar. The inspector must determine that the mortar conforms to the specified requirements and that tiles are set level with even joints and are solidly embedded.

WALLS AND PARTITIONS

Various types of materials are used as finishes for walls and partitions. With space being limited, we will take up only two types here; they are dry-wall construction and tile.

Dry-Wall Construction

Dry-wall construction has been developed as an economical finish for walls, because of the increased cost of plasterwork and relative scarcity of expert plasterers. Essentially it consists of panels of wallboard of various types with joints tight, true, and effectively concealed. The inspector must be sure that the studding or other frame on which the wall is to be installed is brought carefully to a plumb true plane, because irregularities cannot be adjusted as in plasterwork. He must ascertain that all materials used are strictly in accordance with the specifications; that the wallboard is applied accurately, usually in panels extending from floor to ceiling without a horizontal joint, and firmly fastened in the prescribed manner; that vertical joints are plumb, tight, and taped, or otherwise concealed as specified; that the wall is coated with the required number coats of heavy-bodied special paints or spackle as prescribed; and that the finished wall is true and uniform in texture and appearance with joints substantially invisible.

Tile

Glazed ceramic tile, glazed vitrified clay tile, and plastic tile are used for wall finishes for baths, galleys, messhalls, hospital rooms, and other applications for which a highly sanitary, easily cleaned, impervious wall finish is required. Tiles are furnished with various types of grooves, ridges, or clincher button heads on the back to assure bond.

The inspector must make sure that the tile furnished conforms to the specifications in kind, quality, size, color, glaze, texture, and grip and that all necessary specials, such as base, corners, decorative band, fixtures, and trim, are of true matching color or of the color or pattern prescribed. He must be sure that the mortar scratch

coat is applied and allowed to dry as specified and is ready in all respects to receive the tile; that the mortar bed for tile is applied in the requisite thickness and made true; that the tile is applied and tapped to true plumb alignment with all joints straight, plumb, or level and of uniform thickness; and that the color schemes and patterns are faithfully followed and correctly executed. He must determine that tile is neatly arranged and cut around fixtures; that wainscotting is extended to the prescribed height; that bases align correctly with the finished floor; that joints are filled with plaster of paris, Keene's cement, or other mortar as prescribed; and that on completion all tile walls are cleaned thoroughly without scratching the glazed surface.

CEILINGS

In view of space limitations, our discussion below on finishes for ceilings will also be held to two materials; they are acoustical tile and acoustical plaster.

Acoustical Tile

Acoustical tiles are available in various materials, such as wood, vegetable, or mineral fiber, perforated metal, or cemented shavings in different thicknesses, shapes, and dimensions and with varying texture, perforations, and joint treatment. They may be nailed, clipped, or cemented in place, depending on the ceiling construction.

The inspector must make sure that the tile, hardware for fastening, and adhesive cement conform to the project specifications or the standard specifications referenced therein. He must make sure that tiles are handled and stored carefully and are not allowed to get wet or even damp, and that all marred, broken, or damaged tiles are culled and not used.

If the tile is installed on suspended ceilings, the inspector must make certain that the furring construction is strong, rigid, and in accordance with the specifications. If wood furring is prescribed, he must be sure that the furring strips are spaced accurately to suit the tile width and that tiles are fastened to them by blend nailing or screwing or by countersunk nailing or screwing through the perforations, as may be specified. If metal furring channels are prescribed, he must assure that the tiles are fastened to the channels with approved coupling devices and hangers. When tiles are applied to a finished solid surface, they are cemented with special adhesives, usually with five spots per tile, one near each corner and one in the center, applied to the back of the tiles, which are pressed into place to a true, level plane. The inspector must make certain that all work is accurate and true to plane and line; that all special fitting around pipes, sleeves, and fixtures is neatly done; and that all tiles adhere tightly to the backing material.

Acoustical Plaster

Acoustical plaster is a manufactured product composed usually of asbestos and rock-wool fibers, lime or cement binder, and an aerating agent, factory blended, ready for mixing with water. It is available in white and in light pastel colors.

The inspector must be sure that the material delivered conforms to specification requirements unless it has been factory inspected; that it is delivered in sealed, identified containers; that it is mixed with clean water in the prescribed proportions in a clean wood box; that it is thoroughly stirred; and that it is used promptly after it is mixed.

Acoustical plaster is usually applied over a scratch course of gypsum plaster. The inspector must make certain that this coat is applied as prescribed, cross scratched for bond, and allowed to dry thoroughly. He must be sure that the acoustical plaster is applied in the prescribed number of coats to the specified thickness; that the undercoats are each leveled, rodded, and scratched; and that the finish coat is brought to a true level surface of uniform texture with a minimum of troweling to avoid reduction is acoustical qualities. The inspector should make sure that the plaster conforms to any special requirements of the specifications, such as porosity, density, or hardness.

TRIM

There are basically three types of trim: metal, wood, and marble. Marble is very seldom used in the Navy, so we will only discuss metal and wood trim.

METAL TRIM

Metal trim may be of aluminum, brass, copper, bronze, stainless steel, or galvanized iron or steel and may be of either hollow metal or metal-covered wood, called Kalamein.

The inspector must make sure that the trim is of the prescribed kind, grade, quality, and thickness of metal; that the dimensions and form of section conform to the details shown; and that the finish is in accordance with the requirements.

The inspector must be certain that all anchors needed are built into the structure in advance and that the fastenings are as detailed, specified, or approved. In many cases special fasteners, such as snaps, clips, or other blend fasteners, will be prescribed. In other cases the trim may be nailed or screwed into wood or lead plugs. The inspector must be sure that all trim is free from dents, nicks, or other imperfections; that all corners are accurately mitered and welded, brazed, or otherwise joined as prescribed; that all reinforcement for locks, hinge butts, and other hardware is provided, accurately located, and rigidly fastened to the trim; and that the trim is anchored tightly to the supporting members with a snug fit. He must make sure that all trim is protected against damage and that all damage prior to acceptance is made good.

WOOD TRIM

Wood trim or millwork may be of either rare or common varieties of hard or softwood. Regardless of species, millwork usually must be thoroughly seasoned, air dried or kiln dried, and free from knots and sap and must have even straight grain.

The inspector must make sure that the trim has been factory inspected or grade marked or that it is of the species, grade, dimensions, pattern, and finish prescribed; that molded lines are true and sharp without fuzz, flats, or splintered edges; and that the material has been suitably dried and is not warped or curled.

The inspector must make certain that the installation is made with the specified quality of workmanship. On high-grade work he must be sure that all trim is set plumb or vertical with square corners; that all corners are miter cut and coped if necessary for close fit on internal corners and provision is made for expansion and shrinkage; that where long runs are installed in more than one piece, miter cuts and lap splices are used; and that where curved bends are needed, the trim is kerfed on the back so that the cuts are invisible from the front and are close enough together to create a smooth uniform curve without kinks. He must make sure that all trim is nailed securely, that nails or brads are suitable to avoid splitting, and that finishing nails are set adequately but not so deeply as to pull through the wood. He must make sure that all joints and visible seams are sealed with wood filler and that all trim is suitably primed and field painted.

DOORS

An inspection of structures should include both exterior and interior doors. The following sections provide information on some of the different types of doors used at Navy activities. Items that should be checked in an inspection of specific types of doors also are pointed out.

EXTERIOR DOORS

Exterior doors may be of wood, steel, bronze, aluminum, or structural glass. Wood doors may be of hardwood or softwood. Metal doors may be of hollow metal, of structural shapes and plates, or of filled-panel construction.

HINGED DOORS are used for most personnel entrances. They may be single-leaf or double-leaf. Two or more pairs of double-leaf doors may be used for main entrances. Hinged doors may be of wood, hollow metal, filled-panel, or rolled-metal construction. They vary in style from simple stock patterns to highly ornamental designs in bronze, aluminum, Monel metal, or stainless steel. Hinged doors may have exposed or concealed hinges mounted on the jamb or top and bottom set in the head and threshold. Most screen doors are of the hinged type.

The inspector must be sure that hinged doors are of the material, grade, size, type, and design specified and conform to the specifications in all respects. Usually, doors will have been factory inspected. The inspector must determine that they are accurately fitted to the frames with minimum clearance at head, jambs, and sill; that they are weather-stripped, glazed, and fitted with hardware as prescribed; and that they are painted, varnished, or otherwise finished as specified.

Large openings may be closed by HORIZONTAL SLIDING or ROLLING DOORS, usually suspended by hangers from rollers that travel on horizontal or slightly inclined tracks and guided by troughs, grooves, or similar devices at the bottom. These doors vary from simple barn doors to the massive steel-framed doors used for airplane and airship hangers. Doors

of this type of large size usually run on wheels mounted in the bottom chord and travel on rails set at grade.

When inspecting horizontal sliding or rolling doors, the inspector must be sure that the doors are plane and free from wind. He must ensure that the doors are mounted so that adequate operating clearance is obtained, but that suitable weathertight closure is also obtained when they are closed. He must make certain that tracks, rollers, roller suspensions, and operators are accurately aligned and adjusted for smooth operation.

Large shop and storehouse openings are frequently closed by STEEL ROLLING DOORS. These doors consist of a large number of interlocking horizontal slats that can be rolled up on a drum mounted above the head of the door opening. The slats are held loosely in channel guides at the jambs. The doors are counterbalanced by a spring tension device for ease of movement and may be operated either by motor or by hand.

In an inspection of steel rolling doors, the inspector must make sure that the slats are true and undamaged and interlock with adjacent slats as intended. He must be sure that the slat assembly is mounted truly on the roller or drum and is correctly fastened so that the slats roll up smoothly and evenly, maintaining their horizontal position. He must make certain that slat ends are provided with guide castings as prescribed or approved, and that these guide castings fit accurately into the side guides with sufficient depth of bearing to assure against their pulling out and with sufficient clearance to assure easy operation. He must assure that the spring counter balance or other balancing device is tensioned for the prescribed ratio of the total load and maintains satisfactory tension throughout the operating range. He must determine that operating machinery is suitably aligned and adjusted, and that all accessories specified are provided and installed.

Alternatively, large shop and storehouse openings may be closed by LIFT DOORS. There are many different forms of such doors. The entire door may be arranged to be lifted vertically in one piece inside the exterior wall. If headroom is limited, vertical lift doors may be subdivided into two or more panels. Each panel is set farther in from the face of the building than the panel above it, sufficiently to provide clearance. The operating devices are designed so that the various panels travel simultaneously past one another at different speeds and reach a common level clear of the opening when they are fully opened. Overhead doors may travel upward and inward so that they reach a horizontal position overhead when opened. Such doors may be in one piece with the motion controlled by two sets of wheels traveling in independent curved guides, may be in several panels traveling in tandom, or may be in panels that telescope and nest in the overhead position. These doors usually are counterbalanced and may be operated by hand or motor.

The inspector must be sure that lift doors are installed accurately; that the operating cables or chains are correctly reeved and adjusted so that the doors operate truly without jamming or skewing; that the doors are counterbalanced as prescribed; and that operating machinery is installed, aligned, and adjusted so as to assure easy, trouble-free operation.

INTERIOR DOORS

Interior doors usually are of wood, hollow metal, or metal-covered wood. Plywood or pressed metal may be used for cabinet doors. Hollow metal doors may be filled with sound-absorbing linings. Doors will be factory inspected. Metal-covered wood doors for use as fire doors may be specified to bear the underwriter's label.

Most interior doors are of the single-leaf HINGED TYPE. Double swing doors will be prescribed for some locations.

SLIDING DOORS may be prescribed for closets and for large openings between rooms. They usually will be arranged to slide into concealed recesses when opened. Fire doors are frequently arranged to slide or roll down an inclined track automatically when released by the melting of a fusible link in the anchoring device.

Doors of numerous special types will be encountered, such as elevator doors, trap doors, Dutch doors, lattice and louver doors, incinerator doors, vault doors, and accordion doors.

The inspector must be sure that all doors conform to requirements and are free from any defects that impair their strength, durability, or appearance. He must determine that all doors are of the prescribed types, that doors and door hardware are installed correctly and accurately, and that doors operate freely and close tightly. He must be sure that sufficient clearance is provided above the finished floor to accommodate floor coverings when necessary. He must also ensure that the swing of the doors is in accord with drawings and schedules.

WINDOWS AND SKYLIGHTS

Special care is needed in the inspection of windows and skylights. Check points to be covered in their inspection, including pointers on the inspection of glazing, are given below.

WINDOWS

WOOD WINDOWS usually are of the double-hung or casement types. The inspector must be sure that panels and sash are of the prescribed species and grade of wood, that they conform to the requirements for each type scheduled, and that they are carefully handled and fully protected against damage. He must be sure that frames are carefully installed plumb and square, that sashes are fitted neatly so that they operate freely but without rattling, that sash weights or spring balances are installed and adjusted correctly, and that all hardware and weatherstripping specified are installed and adjusted satisfactorily. He must determine that casement sashes are hinged to swing in or out as shown, that they fit accurately and are suitably weatherstripped, and that operators, bolts, and other hardware are accurately positioned and adjusted.

STEEL AND IRON WINDOWS are available in many types. Among the more common are double-hung, pivoted, commercial projected, architectural-projected, casement, top-hinged, continuous, and detention or security types. The inspector must be sure that the windows are of the prescribed type, size, grade, and section of members and conform to the specifications in details and workmanship, and also that the windows installed in each opening conform to the schedule shown or specified. He must make certain that windows are carefully handled and stored, and are free from distortion when they are installed. He must be sure that all anchors, bolts, and clips needed for fastening the windows in place are installed; that frames are set accurately and truly and are calked as prescribed; that ventilators are set accurately and adjusted so that they operate freely and close tightly; and that all operators and other moving parts are made to operate smoothly and easily without strain.

Most ALUMINUM WINDOWS are built of extruded shapes of relatively light section. They are available in most of the types listed for steel windows in the preceding paragraph but are generally of the double-hung or casement types. Requirements for inspection are substantially the same as for steel windows. The inspector must be sure that aluminum is of the grade and temper prescribed. Usually the manufacturers caution that windows must be kept locked and not opened until they are set and glazed. The inspector should insist that this practice is followed. He must determine that care is taken to avoid marring the members during installation, because of their relative softness.

SKYLIGHTS

Skylights of the framed type may be constructed of galvanized iron, asbestos-protected metal, copper, aluminum, stainless steel, or Monel metal. The inspector must be sure that the skylights conform to the details shown; that all necessary steel supports, base curb, and reinforcement are provided; that skylights are flashed to all adjoining work in a watertight manner; that bars are provided with suitable shoulders for the support of the glass and with gutters for the collection of condensation; that glass is set on felt or in putty as prescribed; and that caps are set and adjusted so as to be watertight without imposing restraint or strain on the glass.

Skylights may be provided by installing corrugated glass in panels on roofs of corrugated types. The inspector must be sure that glass is of the type, thickness, and size prescribed. He must make certain that the glass is fastened securely, but without restraint or strain, and that the installation is made completely watertight.

GLAZING

Glass may be clear window, polished plate, processed, rolled figured sheet, figured plate, wire, prism, corrugated, safety, or heat-absorbing glass.

The inspector must make sure that the glass for each location is of the type, grade, thickness, surface finish, color, and size prescribed and conforms to all requirements of the project specification or referenced standard specification. He must determine that putty is of the type and quality specified and that all points, clips, and other devices conform to requirements. He must be sure that all glass is carefully handled, stored, and protected from damage.

The inspector must assure that all glazing is correctly done; that glass is held in wood with zinc glazier's points and in metal with

approved spring clips; that glass is neatly bedded in putty or back-puttied as prescribed; that glass is set with uniform bearing and without strain; and that stops or beads are installed where prescribed. He must be sure that all figured glass is set with the correct face out. He must make certain that all stains, labels, and excess putty are removed; all broken glass replaced; and all glass cleaned and polished as prescribed.

PAINTING

An inspector needs to possess a thorough knowledge of paint materials, equipment, and painting procedures. He must also be able to inspect both exterior and interior paint jobs involving different types of surfaces.

STEEL STRUCTURES

Thorough preparation of the surfaces to be painted is the most important and most frequently slighted element of good painting. It is of particular importance if paints with synthetic resin vehicles are to be used, because they require exceptionally clean, dry surfaces for satisfactory results. The inspector must be sure that steel surfaces are cleaned by wire brushing, sandblasting, gritblasting, flame cleaning, cleaning with solvent, or airblasting, as may be specified; that all surface rust, dirt, grease, oil, and loose scale are removed; and that tight scale is also removed, if so specified. If the use of chemical rust removers is prescribed or permitted, he must make sure that the preparation is of an approved type and is brushed on thoroughly and allowed to dry, and that all loose material is brushed off. Galvanized surfaces must be killed with dilute muriatic, phosphoric, or acetic acid, rinsed, and allowed to dry, or treated with approved proprietary treating agents as may be specified.

The inspector must be sure that ready-mixed paint, which tends to settle in the container, is thoroughly remixed to uniform consistency by hand or power stirring. Usually it is necessary to pour off the lighter fluid into another clean container, stir the heavier residue until it is uniform, and then add the lighter liquid gradually, with continuous stirring, until the paint has been worked to a smooth, even, homogeneous mixture. The inspector must make sure that paints delivered with pigments and vehicles in separate containers are similarly mixed, preferably with power stirrers. Color usually is furnished as color-in-oil and in paste or liquid form. The inspector must make certain that color is added in the correct quantities to assure a uniform tint for each field coat and that, when specified, the quantities for successive coats are varied to distinguish the coats and facilitate inspection. The inspector must make sure that thinning is permitted only when specifically authorized and that the amount of thinner added is limited to the minimum required for satisfactory application.

The inspector must be certain that paint is applied only under satisfactory atmospheric conditions. The specifications usually will prescribe the minimum temperatures at which painting may be done. The inspector must assure that paint is not applied in a highly humid or rainy atmosphere, or when condensation on the metal surface may occur. He must be sure that the paint surface is visually dry before permitting painting to proceed. Specifications may prescribe application by brush or spray or permit either method. If paint is applied by brush, the inspector must be sure that each coat is thoroughly worked with suitable brushes until a smooth, even coat is obtained, free from brush marks, laps, holidays and drips of excess paint. He must ascertain that paint is worked thoroughly into all joints, cracks, and crevices. He should check the coverage obtained and verify that the area covered per gallon is within acceptable limits. He must make certain that each coat is allowed to dry thoroughly before the next coat is applied, and that the prescribed number of coats, each conforming to the requirements of the specifications, is applied.

EXTERIOR PAINTING

The inspection of exterior paint jobs will involve woodwork, metalwork, and concretework. The inspector must know what to look for in inspecting each type of surface.

Woodwork

The inspector must make sure that surfaces are thoroughly dry and clean and are otherwise suitably prepared for painting before permitting work to proceed. He must determine that the priming coat is intact and of suitable consistency to protect the wood, but not so tight that moisture in the wood is prevented from evaporating. For exterior work, sandpapering will not be prescribed. The inspector must be sure, however, that the wood is smooth enough to assure the continuity and adherence of the paint film. He

must make sure that holes and cracks are puttied or filled with wood filler, and that knots and pitch streaks are sealed with shellac, varnish, or other sealer as prescribed.

The inspector must be certain that paints are of the prescribed type and quality; are mixed, colored, and thinned to provide a paint of uniform consistency and color; and are applied by brushing, using high-quality brushes, until the coat is smooth, even, free from brush marks, and of uniform thickness, texture, and color. He must be sure that all cracks and crevices are sealed and that the paint is not brushed too thin to assure satisfactory hiding power. He must make certain that each coat is allowed to dry thoroughly to a firm film before permitting application of the next coat and make sure that the specified number of coats is applied. Staining of shingles and trim may be performed by dipping or brushing. The inspector must be sure that in dipping, the material is loosened so that the stain reaches all immersed surfaces and is left immersed until stain has fully penetrated the grain; that excess stain is drained off; and that stain is replenished and stirred to assure uniformity.

Metalwork

Requirements for inspection of painting of exposed ferrous metalwork have been described in the section entitled "Steel Structures." Nonferrous metalwork usually is not painted. When painting is prescribed, the inspector must be sure that surfaces are prepared, primed, and painted as specified. Inspection procedures as described earlier for steel structures are generally applicable.

Concretework

Painting of concrete, stucco, and similar surfaces is done primarily for decorative purposes or for dampproofing walls. Paints usually are of white portland cement base with color, but may be of oil base. The inspector must be sure that the materials conform to the project specification or the applicable referenced standard specifications. He must determine that surfaces are clean and free from dust, efflorescence, and other contamination and are adequately cured. If portland cement paint is to be used, he must be certain that the surface is thoroughly wetted. If oil-base paint is to be used, he must assure that the surface is thoroughly cured, pretreated as prescribed, and thoroughly dry. Inspection of application should conform generally to the instructions for inspecting painting of exterior woodwork.

INTERIOR PAINTING

Paint for interior WALLS AND CEILINGS usually will be a flat wall paint. For small jobs the specifications may permit the use of approved commercial ready-mixed paints. Interior enamel may be prescribed where a semigloss or gloss washable finish is desired on woodwork or walls. The specifications may prescribe a standard undercoat for primer under enamel, or may permit the use of the enamel with thinner. Paint and enamel may be obtained with color added, or color-in-oil may be added to the white paint on the job.

Requirements for inspection of interior painting are in general the same as those described above for exterior painting. Specifications may require sanding of interior woodwork or rubbing with steel wool and may require priming of plaster surfaces with a glue size. The inspector must be sure that finish coats are of uniform gloss and color and are free from suction spots, highlights, brush marks, and other imperfections. The inspector should note that color in most interior paints lightens appreciably in tint when dry and tends to fade, while color in exterior paints tends to darken after continued exposure. Staining and varnishing may be prescribed for hardwood trim and millwork.

New WOOD FLOORS are seldom painted or stained. Usually, hardwood floors will be given a floor coat, one or two coats of floor sealer, and a polished wax finish. Varnish or shellac may be prescribed for floors of emergency or temporary structures. The inspector must be certain that all materials conform to the specified requirements.

The inspector must be sure that wood floors are machine sanded to a uniform level surface and that all sand and dust are completely removed. He must determine that paste wood filler, thinned with turpentine or mineral spirits if necessary, is brushed thoroughly into the surface; that the excess is removed by scrubbing with burlap; and that the filler is allowed to dry thoroughly. He must be certain that floor sealer, if prescribed, is applied liberally in one or two coats as specified; that all excess sealer is removed; and that the surface is buffed and burnished, if required, and allowed to dry and harden thoroughly. If wax polish is prescribed, he must assure that the wax is applied

in paste or liquid form as specified or permitted, spread uniformly and thinly, and polished with a power-driven polishing machine. He must make sure that areas inaccessible to the machine are rubbed by hand. Asphalt tile and rubber tile may be required to be waxed. Inspection procedures should be the same as for wood floors.

SPECIAL WORK

ALUMINUM windows, doors, and trim usually will not be painted, but will be given an alumilite or other anodic surface treatment at the factory. When painting is specified, it will be necessary to clean the surface thoroughly, so that it is free from all dust, dirt, oil, and grease; apply a primer of the type prescribed; and apply one or more field coats of paint as prescribed.

Where dissimilar metals are in contact, GALVANIC ACTION may occur that causes the rapid corrosion of the anodic or positively charged material. Magnesium, zinc, and aluminum corrode when in contact with steel; steel and iron corrode when in contact with copper, brass, or bronze; and copper and its alloy corrode when in contact with the precious metals. Zinc coating protects steel at the expense of the zinc coating. The inspector must be sure that aluminum is well isolated from steel and steel from copper by felt, varnish, or other method as specified. Cathodic protection by impressed current is another method of resisting galvanic action.

Metal work exposed to continued or periodic immersion in water is frequently protected by COAL-TAR ENAMEL. It is imperative that such materials be applied in strict accordance with specifications. The inspector must make sure that the entire surface is thoroughly clean and dry and that atmospheric conditions are such that condensation cannot occur. Temporary dehumidification may be necessary. The inspector must assure that coal-tar primer is of the specified grade and is applied at suitable temperature and that complete coverage is obtained. He must determine that coal-tar enamel is flowed or mopped on to the prescribed thickness and is free from holidays. Special care must be taken to make sure that edges of structural members are fully protected. If prescribed, the coating must be tested by a flaw detector of approved type.

COAL-TAR or ASPHALT paint may be prescribed for the protection of smokestakes, breechings, and other installations where coal-tar enamel would not be suitable. These paints vary considerably in type, composition, and characteristics. The inspector must make certain that the material conforms to the specifications and is applied so as to provide a coating of the prescribed thickness, free from flaws and holidays.

Before paint can be applied successfully to bright GALVANIZED METAL, the surface film must be removed and adequate tooth provided by treating the surface with dilute hydrochloric, phosphoric, or acetic acid. A 5-percent solution usually is prescribed. The inspector must determine that the surface is completely treated and is then rinsed thoroughly with clean water. A small amount of lime sometimes is added to neutralize any residual acid. When dry, surfaces so treated are primed and painted like other metal work.

CHAPTER 11
CONSTRUCTION INSPECTOR: ADDITIONAL STRUCTURES

In the preceding chapter you learned various items to be checked in inspecting the construction of buildings and other such structures. The subject of inspections is continued in this chapter. We will discuss inspection requirements applicable to pile, concrete, and timber construction, in which case various types of structures may be concerned. Inspection of piles, for instance, may involve waterfront structures, as well as foundations of buildings and other structures on land where piles are used. We will also discuss check points to be covered in inspecting specific types of structures, such as bridges, cofferdams, and wharves. A thorough understanding of the material in these two chapters should give you an idea of the important role of the inspector in inspecting structures involving light, heavy, and concrete construction. Bear in mind that here, as in the preceding chapter, we are concerned with inspections of new construction, rather than with maintenance inspections of existing structures. Information on maintenance inspections of existing structures is presented in chapter 12.

PILE CONSTRUCTION

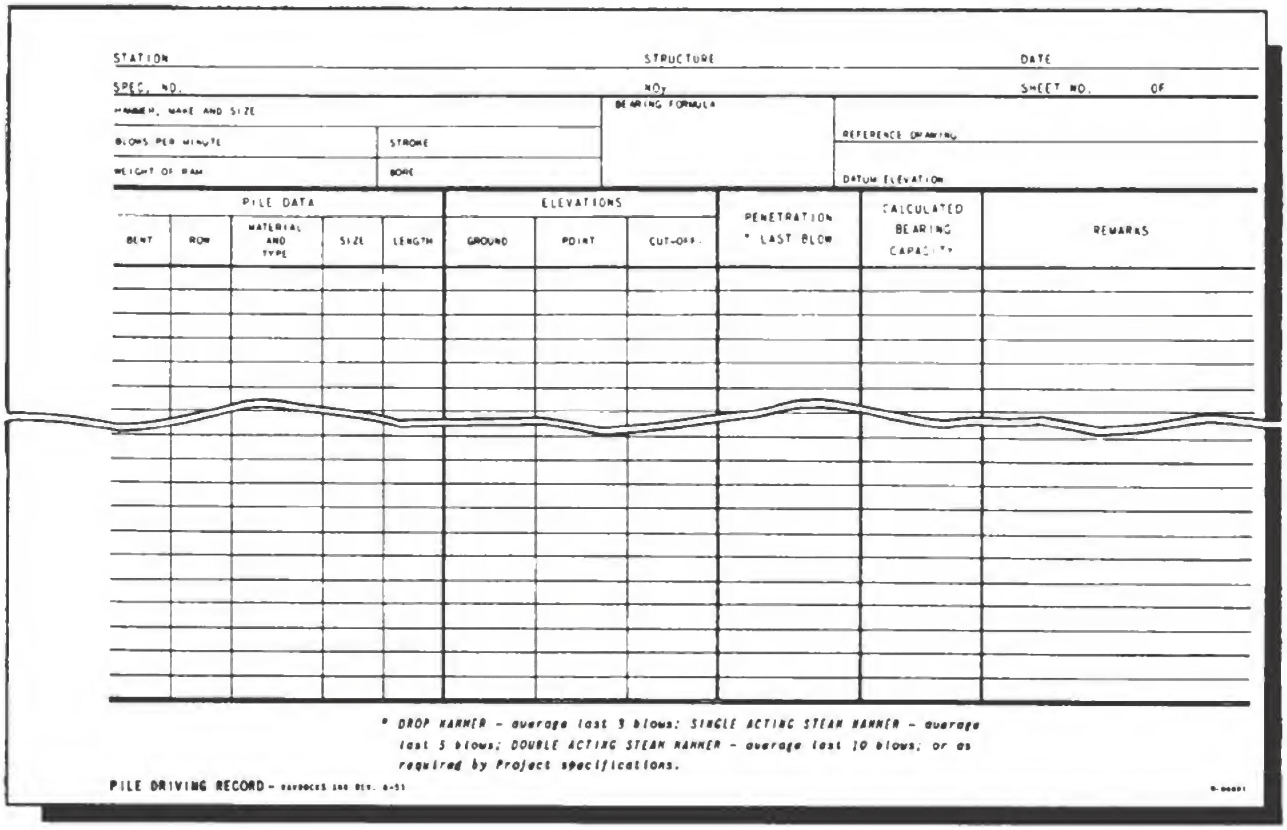
The inspection of pile driving is an extremely important phase of an inspector's duties. There is probably no other type of construction work that requires quick, sound decisions to be made on the spot as frequently. Every inspector assigned to supervision of pile-driving operations should familiarize himself thoroughly with all details of the materials, equipment, and techniques used in pile driving and of the application and limitations of the methods of evaluating safe bearing capacity.

PILE DRIVING

The accuracy with which piles must be located varies with the character of the work. Extreme accuracy in positioning is not essential, for example, in a large mat foundation supported on piles at relatively wide centers. It is important in closely spaced footing clusters, and particularly important in such cases as bridge bent piers, in which the upper part of the pile is exposed and any misalignment is immediately noticeable and objectionable. The inspector must make sure that piles are positioned with the accuracy required by the circumstances, but he should avoid arbitrary and unduly burdensome requirements when they are not reasonable. When close tolerances are essential, the specifications may require the use of templates to assure proper centering. In such cases, the inspector must make sure that the templates provided are strong enough to withstand the abuse to which they are subjected, and that they are maintained square and rigid.

Care must be taken to see that the pile is handled without undue strain or shock, that the pile is set plumb in the leads, and that the pile-driver leads are themselves plumb. Special attention must be given to the rigs used for lifting precast concrete piles, to prevent overstraining and cracking the piles. It is difficult to reposition a pile that has been started slightly out of position; and it is almost impossible to straighten up a pile that has been started crooked.

The inspector must be present during the driving of every pile incorporated into the permanent structure and must keep a detailed record of the driving on "Pile-Driving Record," NAVDOCKS Form 140. (See fig. 11-1). It is imperative that all items on this form be filled out completely and accurately and that any special circumstances be noted in the "Remarks" column. Care must be taken that the hammer data reported represent actual and not nominal performance. The bearing formula used should be that given in the specifications. If none is given therein, request instructions from your superior on the formula to be used. Care must be taken to use the correct dimensional units in applying the formula.



STATION　　STRUCTURE　　DATE

SPEC. NO.　　NOy　　SHEET NO.　　OF

HAMMER, MAKE AND SIZE

BEARING FORMULA

BLOWS PER MINUTE　　STROKE

REFERENCE DRAWING

WEIGHT OF RAM　　BORE

DATUM ELEVATION

PILE DATA					ELEVATIONS			PENETRATION * LAST BLOW	CALCULATED BEARING CAPACITY	REMARKS
BENT	ROW	MATERIAL AND TYPE	SIZE	LENGTH	GROUND	POINT	CUT-OFF			

* DROP HAMMER - average last 3 blows; SINGLE ACTING STEAM HAMMER - average last 5 blows; DOUBLE ACTING STEAM HAMMER - average last 10 blows; or as required by Project specifications.

PILE DRIVING RECORD - NAVDOCKS 140 REV. 6-51

117.297
Figure 11-1.— Pile-Driving Record, NAVDOCKS Form 140.

The inspector must make sure that the hammer used is heavy enough to be effective, considering the weight of the pile. Hammers that are too light waste their energy in impact and inertia effects. So little force is effective in driving the pile down that grossly erroneous indications of bearing capacity, far above what the pile will actually sustain, are obtained. The hammer must strike the pile squarely, or additional energy will be lost in springing the pile sideways. If batter piles are being driven, the inspector must make sure that the leads are set for the proper batter and that the piles are held true to top position and batter as they are driven. If timber piles are being driven, the inspector must make sure that protective rings of proper size are used at the heads of the piles to protect them from splitting, and that pile shoes of approved design are used and properly secured when called for or required.

Driving of piles through many types of soil can be facilitated by the use of JETTING. The inspector must follow the specifications insofar as they prescribe specific requirements for jetting. Usually, jetting is done by one or more pipes with nozzles hung from the driver and operated independently of the pile. Some precast concrete piles have been used with the jet pipes cast in the piles. Such cast-in jets cannot be moved around as needed to obtain best effectiveness, and their use has been largely discontinued. The inspector should permit the widest latitude possible regarding methods of jetting. However, he must make sure that jetting is discontinued a sufficient distance above the final point elevation of the pile to ensure that the point is in undisturbed soil and that the bearing capacity calculated from the average penetration of the last few blows is a reliable index.

The inspector must make sure that piles are driven to the minimum point elevation specified, or to the minimum penetration below the ground, bottom of footing, or mud line, as may be specified. If neither point elevation nor minimum

penetration is shown or specified, the inspector should make sure that the driving is continued until the penetration per blow is reduced to the limit indicated by the formula for the required bearing capacity. If jetting is permitted, the inspector must make sure that the driving is continued into undisturbed material. If the required bearing capacity is obtained with very short piles, the inspector should report the situation to his superior promptly and request further instructions.

Requirements for CUTTING OFF piles vary with the character of the work. The inspector must ascertain the specification requirements governing tolerances of cutoff. Special accuracy is needed when precast caps, stone masonry, or timber caps or grillages are to be set on top of piles. Less accuracy is required when the tops of the piles will project into concrete cast in place around them. In the former case, the inspector must make sure that the necessary accuracy in elevation of cutoff is obtained and that the tops are cut off to a true plane, with the use of a template if necessary.

Cutting off piles under water requires special equipment and extremely careful technique, particularly in tidal waters or rivers in which the stage is variable. When feasible, it is preferable to use a traveling carriage supported on piles to carry the cutoff saw, which is suspended on a vertical shaft, adequately braced. When this is impracticable and it is necessary to use floating equipment, special precautions are necessary to assure accurate cutoff elevation. This is usually done by establishing horizontal range sights on shore and by bringing marks on the saw spud or shaft assembly carefully to this level.

Piles are occasionally designed to resist uplift. In such cases, the pile must project further into the foundation and be notched to provide an upward bearing at a distance below cutoff sufficient to preclude failure in shear above the bearing. The inspector must make sure that the piles are carefully shaped to the required form and that the heads of the piles above the bearing shoulder are sound.

BATTER PILES are usually driven by swinging or pendulum leads pivoted to the fixed pile-driver tower, or by fixed leads held at the proper angle by suspension from a crane, but accurate control of driving is extremely difficult and results usually are unsatisfactory. The inspector should satisfy himself that the methods proposed are adequate to assure satisfactory results. He should make sure that the rig provides a true axial impact and that the piles do not spring sideways excessively under the blow. He must make sure that piles are driven to the specified depth or point elevation, making allowance for the slope distance.

When it is necessary to drive timber piles longer than they can be obtained economically as single sticks, two piles may be spliced. Also, an uncreosoted lower section may be joined to a creosoted upper section by splicing when the short length requiring preservative treatment makes it economical to do so. The inspector must make sure that the splice is carefully made in accordance with the drawings and specifications, with abutting faces in full tight contact, with sleeves driven or wedged tight, and with bolts or lag screws made tight and driven in tight holes. The splice is unavoidably a point of weakness, and the fullest care should be taken to make it as rigid as possible.

Steel H or pipe piles can be spliced readily by welding an upper section on the lower one after the latter has been driven nearly to grade. This method is frequently adopted for very long piles to make excessively long leads unnecessary. The inspector must make sure that the sections are aligned axially, that full square bearing is obtained, and that the welding is carefully and properly done. Steel piles are frequently of high-carbon steel to provide resistance to deformation under impact, and therefore special precautions are necessary in welding techniques to assure a satisfactory weld.

Cast-in-place piles are lengthened by adding sections to the shells as required. Precast piles can be lengthened only by building up a pedestal, reinforced as necessary, to compensate for overdriving.

Cast-in-place piles can be driven on top of wood piles by the use of specially designed sleeve joints furnished by the manufacturers of the shells. Precast piles can also be driven on wood-pile lower sections. A sleeve is usually cast onto the point of the precast pile and securely anchored into it. The inspector must make sure that the field connection is true and tight in all respects and conforms to the details shown.

DIFFICULTIES IN PILES

Various defects are encountered in working with piles. Some of the common types of defects which the inspector may encounter in wood and concrete piles are discussed below.

Wood Piles

The inspector must be alert to detect and take steps to correct deficiencies in equipment and methods leading to defective wood piles. Overdriving or use of too high a fall with drop-hammers may lead to such defects as brooming, breaking, shearing, twisting, or shattering of the pile. The inspector must learn to recognize the indications of such failures and must require that methods be modified, if necessary. Overdriving is usually indicated by bending or staggering of the pile and bouncing of the hammer. Breaking or shearing is indicated by sudden resumption of easy driving after the pile has apparently been driven to practical refusal. Similar behavior may occur when the pile breaks through a hard crust into a softer stratum. Sudden hard driving may indicate that the pile has struck a boulder. Sudden change of direction may indicate that the pile has sheared or broken, or that the pile has glanced off a boulder. The inspector should inform his superior if such difficulties recur and he is in doubt as to the cause. He should appreciate that damaged piles may endanger the safety of the structures that they support.

Concrete Piles

The principal difficulties encountered with PRECAST CONCRETE PILES are cracking and spalling or shattering of the head.

Cracking may occur from faulty mixes or curing, but usually occurs from carelessness or improper rigging in handling. Piles should be inspected frequently and minutely during driving to make sure cracks do not exist. They are particularly dangerous in the portion above the mud line, where they may permit corrosion of the reinforcement to occur. If numerous cracks occur, the situation should be reported to your superior so that a full engineering investigation can be made and the causes corrected.

Spalling or shattering of the heads usually occurs in precast concrete piles because the proper followers and driving blocks are not used. The equipment should be modified if these troubles develop consistently. Piles with badly shattered heads cannot be repaired effectively so that they can be driven with assurance that full bearing capacity is obtained. It may, in extreme cases, be necessary to remove and replace the pile. If the pile is not damaged badly enough to warrant rejection, the inspector should require the removal of all unsound concrete and building up to the finished cutoff.

With CAST-IN-PLACE PILES, difficulties are sometimes experienced through tearing of the shells, or partial collapse after the mandrel is removed. A customary emergency measure is to drive a second shell inside the damaged shell. All shells should be inspected by throwing a beam of light down the shaft with a mirror and determining that they are sound, intact, and tight. Piles that are rejected as defective must be filled with concrete to eliminate a hole in the ground that could subsequently decrease the bearing capacity of adjacent piles.

The principal difficulties encountered with STEEL PILES are twisting and distortion of the heads. Special care must be taken to see that caps of proper design to prevent this action are provided.

CONCRETE CONSTRUCTION

All concrete construction must be in accordance with NAVFAC Specification 13Yh, except as specifically modified by the project specifications. Inspectors assigned to inspection of concrete construction must have a thorough understanding of the requirements of the standard specifications, of the reasons for these requirements, and of the best techniques and methods for meeting them.

The standard specifications necessarily cover a wide range of possible conditions and allow a choice of types of cement, sizes and types of aggregates, and classes of concrete. The specific requirements for each project must, therefore, be set forth definitely in the drawings and specifications for the work. The inspector should verify that all variables and options permitted by the standard specifications are fixed by the project documents, and should call any apparent omissions to the attention of his superior.

PREPARATORY WORK

As soon as the plant is set up for producing and delivering concrete, the inspector should familiarize himself with the functional arrangement and check all equipment to make sure that it is in good working order and accurately calibrated. He should be present at any trial runs made and make sure that any deficiencies that develop are corrected. If any serious deficiencies are apparent that cannot be readily overcome and that might affect the efficiency of the operations,

the inspector should inform his superior of the situation.

Before permitting any concrete to be placed, the inspector must satisfy himself that all excavation has been completed; that banks have been stabilized or protected by bracing, sheeting, or sheet piling as necessary; that excavated areas have been dewatered and plant provided adequate to assure that working areas can be kept dry; that all dowels, anchors, inserts, and similar devices have been placed properly in all previously constructed work; and that all contact surfaces have been carefully cleaned of all debris and laitance and roughened if necessary. Immediately before concrete is placed, the inspector must see that all contact surfaces are wetted and broomed with neat cement grout.

The inspector must make sure that the forms comply in all respects with the applicable requirements of NAVFAC Specification 13Yh; are of the materials, surface type, and smoothness specified; are amply strong and properly tied together to withstand the hydrostatic pressure of the wet concrete; are tight against leakage of mortar; are true to line, grade, and shape; and are rigidly supported so that settlement, misalignment, yielding, or spreading will not occur under the weight or thrust of the concrete; and that forming for openings and recesses has been provided in strict accordance with the plans. If old forms are being reused, he must make sure that they have been properly repaired and cleaned. If the forms are of considerable height, he must see that openings have been provided as necessary for placing concrete without excessive drop. Before placing of concrete is started, he must make sure that all debris has been completely removed from inside the forms and that the contact surfaces of the forms have been wetted, oiled, or coated as prescribed. Generally form contact surfaces are oiled before the reinforcement is set in place.

All reinforcement must be checked in detail to make sure that it is of the specified size, length, type, form, and spacing; is clean and free from loose rust or scale; is firmly secured by approved devices against displacement; and is accurately located to assure that the required cover will be obtained. Splices must be checked for location, length of lap, and clearances between bars. When welded butt or lap splices are required or permitted, the inspector must check the quality, size, and amount of weld.

The inspector must be sure that all anchors, inserts, dowels, sleeves, pipes, and similar fixtures that have to be embedded in the concrete are accurately placed and firmly secured to the forms.

PLACING

When ready-mixed concrete is to be used, the inspector must make sure that the requirements of NAVFAC Specification 13Yh for the method of mixing and delivery are fully met. When job mixing at a central plant at the site is adopted, the inspector must make sure that the methods of transporting the concrete assure rapid delivery without segregation or loss of material.

Concrete may be conveyed from the mixer or delivery point to the forms by barrows, buckets, chutes, pneumatic methods, pumping, or tremie. The requirements and limitations or NAVFAC Specification 13Yh for the method used must be strictly met. The inspector must make sure that methods and equipment meet with the approval of his superior when so required. He must, in all cases, be satisfied that the concrete as placed is acceptable in all respects, and must require correction of deficiencies in methods or equipment if the concrete is not of acceptable quality.

The inspector must make sure that the concrete is deposited without dropping and without displacing the reinforcement; that, as placed, it is uniform and free from segregation; that it is effectively compacted by spading, vibration, or other specified means; and that all other specification requirements applicable to the project are fully met. He must make sure that construction joints and expansion joints are provided at all required locations and are properly located and formed. If concrete is placed in cold weather, by tremie, or under other special circumstances, he must make sure that the special precautions required are taken.

FINISHING

Because NAVFAC Specification 13Yh provides for various types of finishes, the inspector must refer to the project specifications to determine the specific types of finishes to be required. NAVFAC Specification 13Yh prescribes clearly the requirements for each type. The inspector must remember the importance of uniformity of finish and surface texture. He should familiarize himself with the proper techniques for achieving satisfactory results and with the causes and methods of avoiding the common defects in finish.

Excessive surface water, for example, results from too wet or too sandy a mix, or from overworking. Such excess water should be removed by blotting methods or by evaporation and not by sprinkling dry cement on the surface. Excessive troweling brings laitance to the surface and gives a surface that soon dusts and deteriorates. Too rapid drying leads to hair cracks. Placing a topping over dry concrete causes alligator cracking from rapid absorption of water by the base course. The inspector must assure himself that the methods and techniques used preclude such defects and deficiencies.

CURING

NAVFAC Specification 13Yh contains specific requirements for the protection and curing of concrete, including special requirements for certain cases. The inspector must determine which requirements are applicable to the project. He should give careful attention to the requirements for length of curing period required and length of time forms or supports must be kept in place. He must make sure that curing methods are such that the concrete is fully protected against drying out prematurely. If membrane waterproofing is permitted, the inspector must make sure that the membrane seal is applied so that no gaps or holidays occur and must require a second application over uncovered areas.

TIMBER CONSTRUCTION

This section relates primarily to inspection of the field erection of timber structures. Some of the major items to be covered in the inspection are given below.

DELIVERY AND STORAGE

When timber is delivered to the site of the work for incorporation into the structure being constructed, the inspector must make sure that it has been inspected and grade marked as required by the specifications or as approved by proper authority, and that inspection certificates have been furnished by the inspecting agency. He must ensure that these certificates are properly identified as pertaining to the material delivered, and that the tally of material delivered is correct. If it is treated material, the inspector must make sure that the inspection reports of treatment are received, are identified, and indicate that the treatment complies with requirements. If inspection before delivery has been waived for any reason, the inspector must make sure that the timber conforms in species, dimensions, and quality to the requirements of the specifications.

The inspector must make sure that all timber is unloaded with reasonable care so that it is not damaged in handling. He must see that special care is taken in handling timber treated with creosote or other preservatives to preclude damage penetrating the more heavily treated surface layer.

The inspector must require that timber be stored in a well-drained area so that it will be clear of the ground; that it be stacked so that there is good circulation of air through the pile; that in stacking, one end be raised so that water will drain off without standing; and that the layers be adequately supported so that the lower layers will not be crushed by the weight of the material above them. The high end of the stack should preferably be cantilevered forward at the top to provide and eave effect. Kiln-dried timber, finish lumber, and millwork must be stored under cover.

FABRICATION

The inspector must allow latitude on the type and arrangement of plant and equipment to be used on the job, but must make sure that the plant is adequate for the work, is arranged to minimize interference with others or with station operations, and is safe. The scope of the plant will depend both on the magnitude of the work and on the extent of manufacture and prefabrication before erection.

When a large volume of repeat work is involved, all cutting, matching, and shaping, and as much prefabrication as practicable will generally be done at a central woodworking plant at the site prior to erection. This procedure assures more accurate work at considerable saving in labor and is to be encouraged as tending to assure a better job. The inspector should give special attention to checking first runs of each production run to make sure that each piece is cut and shaped to correct dimensions and pattern. When required by the project specifications the inspector must check to see that all fabrication is accomplished prior to treatment.

Prefabrication or preassembly may be practical on a larger scale is the character of the work

permits. The inspector should check all jigs and fixtures used in such processes to make sure that the units are true to exact dimensions within permissible tolerances, and that the units are complete in all respects with attachments, holes for field bolts, and grooves for ring connectors as required. The inspector must also make sure that handling devices for the completed units are adequate to assure their conveyance without distortion or damage. If the material is treated, he must make sure that all cuts and holes are given the surface treatment specified.

ERECTION

The erection plant will usually consist of automotive or locomotive cranes or travelers, with the necessary slings, strongbacks, and lifting devices. The inspector must make sure that the plant is adequate, safe, and in good working order and must record the plant on hand and in use in his daily reports.

The inspector must make sure that the erection methods are safe and capable of performing the work effectively and are of required workmanship and quality. He must make sure that all members are of the correct dimensions and are cut square or formed to exact shape; that they are fitted together truly with full bearing and without shims or other adjusting devices, except as specifically permitted; that bolt holes are round and undersized for drive fit; that all members are aligned correctly; that the work is adequately braced, guyed, or supported at all times to assure against distortion or collapse; and that all bolts, driftpins, ring connectors, and other hardware are of the specified dimensions and materials, are galvanized if required, and are properly installed and tightened or driven home without damaging the timber. The inspector must reject and require replacement of any timber or hardware damaged during erection. The inspector should make sure that temporary holding or aligning devices are provided and used as necessary to assure tight, accurate work, that these devices do not injure or mar the finished work, and that they are removed upon completion of erection. On work involving the connection of a number of plies of heavy material, it is essential that ample length of tread be provided to allow for future retightening of bolts if the timber shrinks. The inspector must make sure that all other detailed requirements of the specifications are fully met.

COFFERDAMS

Cofferdams are temporary structures enclosing an excavation, either on land or in the water, so that the work may be performed in the dry. If in water, they must be strong enough to resist hydrostatic head from maximum high high water to the mud line and the lateral pressure of saturated soil from the mud line to the bottom of the excavation. If on land, they must resist the pressure of dry earth above the ground water line and of saturated earth below it. They must be substantially watertight and must penetrate far enough below the bottom of the excavation to afford an adequate cutoff to minimize seepage, blowouts, and boils through the bottom of the excavation.

The inspector is respónsible for inspection of the construction and maintenance of the cofferdam from the stand of safety of the work as a whole. He should familiarize himself with the approved plans for the cofferdam and with the basic principles on which it was designed, and is expected to act so that he can determine intelligently whether the work is being performed correctly and in proper sequence for safety.

In some cases, various types of fixed or floating templates, or other alignment devices such as guide piles, are provided to establish and maintain the lines of the cofferdam walls. The inspector should make sure that they are laid out so that the permanent structure can be built within the cofferdam without interference, with due allowance for possible deflection or displacement of the cofferdam.

The inspector should watch the construction of the cofferdam and satisfy himself that sheet piles are being driven to the depths indicated, that piles are properly interlocked, that bracing is installed and adequately wedged before excavation or dewatering has proceeded too far, that any berms or embankment needed for the stability of the cofferdam are constructed in time, and that any clay blankets shown to decrease percolation are installed before pumping is started. He should make certain that adequate pumping plants or well-pointing systems have been provided and are in working order. The inspector should point out any seeming deficiencies in workmanship or sequence of work, and should keep his superior informed of any serious deficiencies that are left uncorrected.

The cofferdam should be maintained in an acceptably dry condition during the construction of the work being built within it. The inspector

should maintain general surveillance of the condition of the cofferdam and point out any evidences of weakness. He must require that the cofferdam be kept dewatered to the level necessitated by the work in progress. He should keep a complete record of all emergency conditions arising and of the measures taken to correct them. The principal troubles arise from leaks, blowouts under the walls, scour outside the walls, overtopping in floods or at extreme high tides, settlement of the cofferdam, crushing of the internal bracing, or failure of the wales. The inspector must not initiate any action himself to effect emergency repairs but must deal with emergency situations through the principal foreman on the spot. Most emergency situations develop slowly enough to permit correction if caught in time. Others occur so quickly that nothing can be done before the cofferdam is flooded. If such a situation develops, the inspector should inform his superior immediately; endeavor to find the causes, for the record; ascertain the repair procedures proposed; and obtain the approval of them by his superior.

Special care must be taken to guard against fire, particularly in cofferdams braced internally with timbers. The inspector must require immediate correction of any hazardous situations noted.

When the permanent work that has to be built within the cofferdam has been completed and found acceptable, the entire temporary structure must be removed, except that the specifications may provide that sheeting may be cut off below ground level or at some elevation below water level and left in place. The inspector must make sure that the structure is entirely removed, except as otherwise provided or authorized by his superior.

WHARVES AND PIERS

The construction of wharves and piers involves steel, concrete, or timber constructions. Inspectors assigned to such projects must be thoroughly conversant with the inspection of the applicable types of construction, and with requirements for inspection of the materials entering into several types of work. This discussion deals with the inspection of wharves and piers that involve three types of construction; they are open timber pile construction, filled timber pile construction, and concrete piers on piles. An inspection of wharves and piles may also include drainage, utilities, and so on; with space being limited, however, these areas of work are not covered here.

OPEN TIMBER PILE CONSTRUCTION

Open timber pile construction is the cheapest and generally the least durable type of construction for wharves and piers. Durability is increased by the preservation of the timber piles and framing, at greater cost. Usually this type of structure consists of timber piles, caps, stringers, and decking, with accessories such as fender piles, wales and chocks, guardrails, tracks, mooring devices, and utilities.

The inspector must make sure that the approved sequence of work is followed. In some cases, dredging of the site must precede all construction in order to preclude unbalanced lateral pressure against the piles, which might occur if the dredging were deferred until after completion of the structure. In some locations where soft mud is present to considerable depths, the drawings and specifications may require removal or displacement of this mud to a given depth, and replacement with a sand island to provide better bearing and resistance to lateral forces. The inspector must make sure that the methods used assure full removal or displacement of the mud to the required depth, that the sand is of specified quality and gradation, that it is placed in a manner that assures its deposit within the specified limits without undue admixture with mud, and that it is allowed time for consolidation before the structure is built. Driving of piles, however, aids in this consolidation.

The inspector must make sure that the piles are driven to the specified depth or penetration, that they are cut off true and level at the specified elevation, and that they are in accordance with the specifications in all respects. He must make sure that all timber is of the correct size, species, and treatment and that hardware is of full size and length, is galvanized when specified, and is installed properly. He must assure the use of wooden shims only as permitted by the specifications. When creosoted piles or timber is required, he must make sure that all special requirements therefore are faithfully met. The inspector must assure the complete and correct installation of all pipes, conduits, and other services, without cutting of strength timbers, and make sure that all fire stops shown are provided as specified.

FILLED TIMBER PILE CONSTRUCTION

In some localities not subject to marine borer attacks, a filled timber pile type of construction is used. Untreated timber piles are cut off just above low water and decked over with timber caps and planking. Concrete curtain walls are constructed along the face of the wharf or pier and anchored to the deck. Earthfill or sandfill is placed on the deck behind the curtain walls to subgrade elevation, and is compacted. Concrete or bituminous pavement is constructed on the fill. Utility tunnels, services, and tracks may be combined with the curtain walls, may be supported on concrete walls or piers built on the deck, or may be constructed in the fill.

This type of structure requires extensive low-tide work, frequently necessitating a special schedule of working hours. In addition to the usual inspection requirements for timber piers, the inspector should give special attention to the requirements for keying and anchoring the curtain walls. He must also make sure that requirements for spacing between deck planks are carefully followed. Too wide an opening permits excape of fill; too narrow an opening may result in buckling of the planking as the wood swells. The inspector must make sure that all structures supported on the deck are installed before the fill is placed, and that the fill is thoroughly compacted under any ducts, pipes, or other installations supported on the fill.

CONCRETE PIERS ON PILES

Many piers are built with reinforced concrete beam and girder decks supported on reinforced concrete or steel H-piles. Wharves of this type may also be built with sheet-pile bulkheads on the shore face of the wharf.

The inspector must give special attention to the driving of piles to make sure that they are accurately aligned and are driven to adequate penetration and bearing value. If they are of reinforced concrete, he must see that they are free from cracks that might cause rapid deterioration, particularly in salt water. If they are of steel, he must make sure that any special protective coating called for in the range between high and low water is properly applied and is at the specified elevation after driving is completed. He must be quick to have the limits of coating modified to suit if the penetration being obtained changes. He must make sure that the reinforcement in the piles is anchored in the caps or girders and that the reinforcement for the latter is installed exactly as shown, to assure that the degree of fixity at the top of the piles contemplated by the design is actually obtained. He must make sure that any conduit or pipes in the slab, any inserts for supporting pipe or duct hangers or for anchoring fenders, and any anchor bolts or other accessories to be set in the concrete are installed and checked in detail before concrete is placed. He must make sure that the specified minimum clear cover is obtained between the reinforcement and the underside of the slab. Serious deterioration of many concrete piers has resulted from failure to comply with requirements for cover over the steel.

RAILROADS

Railroads are required at many Navy activities and it is important that they be properly constructed. Various factors to be considered in inspecting construction involving railroads are given below.

ROADBED

The earthwork involved in preparing the railroad roadbed is comparable to that required for highway construction, and methods and equipment used are generally the same. The inspector must make sure that all unsuitable material is entirely removed as specified, that earthwork is placed in layers of prescribed thickness and is compacted to the specified density, that sections are full, and that side slopes are not steeper than allowed. Special attention must be given, where required, to protection of freshly formed side slopes from erosion.

Railroad roadbed drainage usually consists of side ditches in cuts; intercepting ditches along the tops of slopes of cuts where the slope of the ground is toward the cut; cross-culverts where it is necessary to carry the stormflow across the tracks; and outfall ditch improvements to carry the stormflow away from the right-of-way of existing natural watercourses. Subsurface drainage may be required occasionally in wet cuts to improve the stability of the roadbed and frequently will be required for railroad tracks in the developed sections of naval activities and in classification yards.

TRACKWORK

The inspector must make sure that all MATERIAL required to be factory inspected has

in fact been so inspected, and that the necessary shipment notices identifying the material delivered and indicating acceptance as conforming to requirements have been received. He must inspect after delivery all material not requiring factory inspection to assure that it conforms strictly to the requirements.

Correct ALIGNMENT of track is essential to satisfactory railroad track construction. The center of the track must coincide with the center of the roadbed, and in developed portions of naval activities frequently must be parallel to street lines. Tangents must be visually straight, with uniformly exact gage. Circular curves must be truly uniform in degree of curvature, and transitions between tangents and curves, where required, must vary uniformly in degree of curvature in strict conformance with the requirements. The inspector must make sure that on tangent track the center stakes are set at 100-foot stations, that the track is set so that exactly one-half the gage distance is obtained from the center-stake tack to the gage side of either railhead, and that the track between stations is brought to true alignment by sighting. On curves above 8 degrees, care must be taken to verify that the gage is increased as specified, or in accordance with standard practice. On crane tracks the gage must be decreased in conformance with the plans and specifications. The inspector must make sure that track is held to true alignment as ballast is placed and tamped. Track gages should be checked periodically with a master gage to assure that they are accurate.

Track must be brought accurately to GRADE as the ballast is placed and tamped. Where grades are compensated for curvature, the inspector must make sure that the track is set to elevations that will provide the specified compensation. He must make sure that each rail is held at the same elevation on tangents and that the specified superelevation is provided on curves. The specifications will usually require correction of grade after rolling stock has been operated over the new track sufficiently to develop soft spots and to effect most of the ultimate settlement. The inspector must make sure that the track is true to grade when finally accepted.

BALLAST for trackwork varies from broken stone, conforming to the standards used on Class A railroads, to graded gravel, bank-run gravel, slag, cinders, shell, coral, and sand. Ballast will usually be inspected after delivery. The inspector must make sure that it conforms in all respects to the project specifications or to the standard specifications referenced therein. Usually the inspector must verify the type of ballast, gradation, and freedom from dirt or other objectionable material. Laboratory tests for abrasion and durability may be required.

Ballast is placed either by dumping it on the subgrade from trucks or by dumping from cars operated on the skeletonized track laid with widely spaced ties on the subgrade, and spreading and tamping it. The inspector must make sure that the full amount of ballast required to form the specified section is placed; that it is thoroughly tamped under, around, and outside the ties; and that it is sloped neatly along the outer edges to the subgrade.

CROSSTIES are generally of treated or untreated timber, except in special cases. Steel ties have been used occasionally for tracks in concrete pavement, and steel plates are frequently used to support crane track rails on drydock copings. Specifications for wood ties usually will prescribe the kinds of wood that are acceptable, the dimensions, and the type, whether sawed or hewn. The characteristics, defects, and requirements on which inspection of wood ties must be based are similar in scope to those for dimension lumber. In inspecting wood ties, the inspector must examine all faces and ends and determine that they are of the type, form, and class prescribed. The inspector must make certain that ties are handled carefully, stacked neatly if held in storage, and set flat with ends in alignment.

The inspector must make sure that RAIL is handled carefully without dropping, that it is straight or bent to true curvature in a horizontal plane as required, and that it is installed with the specified expansion openings at the joints. Inadequate openings cause buckling of track in hot weather; excessive openings may result in shearing of the joint bolts in cold weather and also cause battering of the rail ends under traffic. Gaps should be adjusted as follows.

Temperature of rail (degrees F)	33-foot rails (inches)	39-foot rails (inches)
0-25	3/16	1/4
26-50	1/8	3/16
51-75	1/8	1/8
76-100	1/16	1/16
Over 100	None	None

TRACK FITTINGS include rail joint bars, tie plates, rail anchors, bolts, spikes, nuts, and washers. The inspector must determine that

joints are fully bolted and that bolts are tightened fully to uniform tension. He must check that tie plates bear fully on the tie and that the rail is firmly seated on the tie plate. He must make sure that all special fittings, such as rail anchors and braces, are installed securely as required, and that spikes are of the specified types and are fully driven by blows in direct line with the spikes to avoid enlarging the spike holes. Spikes should be staggered on opposite sides of the rail, and also staggered opposite hand for the other rail, to preclude gradual rotation of the tie out of square.

SWITCHES AND TURNOUTS

A standard set of special switch ties of graduated length will be required for each switch, as shown on the drawings or as specified by references to standard specifications. The inspector must make sure that such special tie sets conform to requirements and are installed in the exact arrangement shown and at the spacing specified so that the switchplates and braces will fit properly.

The inspector must make sure that the point of switch or turnout is accurately located, that all switchplates and braces are correctly applied, that the exact throw of the switch is provided, and that the switch points fit properly to the running rails when switch is lined for a specific track. Exactness of alignment must be demanded, especially of the lead rails, that is, the rails between heel of switch point and toe of frog. Switch construction normally requires the use of short rails. Frequently it is necessary to cut standard-length rails to provide correct length of rail required and to drill holes in the cut section of rail to provide for joint bolts. The inspector must ascertain that the holes are properly drilled with a rail drill and must under no circumstances permit a hole to be burnt in a rail with a torch.

The point of the frog must be accurately located. Guardrails must be properly installed and the prescribed gage distance of guardrails obtained. Frogs must be securely spiked and firmly seated on the special ties furnished.

Switch stands must be located on the side of track as shown on the plans. They must be firmly spiked to the switch ties and adjusted so that when the switch is set for the main line or lead track the switch rod is in tension. Adjustment of the throw lever must be such that it is securely held in position by the switch latch or lock.

CRANE TRACKS

Because of the heavy wheel loads to be supported, drydock crane tracks require special foundations. Rails are carried either on the side wall of the drydock or on independent continuous girders under each rail, supported on piles, with cross-struts to assure maintenance of exact gage. Rails are set on steel plates carefully brought to true line and grade. The inspector must determine that the drawings and specifications are followed strictly, and that the rails are exactly true to alignment and grade and firmly and permanently bedded. Particular care must be taken to follow the specifications in respect to the steel tie plates because in some cases shimming and grouting are permitted to obtain true grades, and in others this practice is prohibited. Substitution of wooden shims or wedges must never be permitted.

Crane rails are usually of extremely heavy section. The inspector must make sure that all track fittings and specials furnished are specially adapted for use with the rail section specified and provided, that alloy-steel specials or inserts at points of maximum wear are provided if specified, and that extreme care is taken to obtain the highest possible quality of workmanship in all installations. Particular care must be taken to assure exact variation in gage on curves and on transitions between curves and tangents in strict conformance with the geometrics shown or specified. Cranes operating on four rails or two pairs of standard-gage tracks require a reduction in gage on curves, which must be met within close tolerances because of the limited sideplay in the wheels, trucks, and equalizing beams.

Split switches are not practicable for heavy crane tracks. Usually, stub switches or turntables are provided. The inspector must verify that the type specified is provided and installed and adjusted with extreme accuracy, to assure that stubs line up precisely with the rails in either position of throw. Turntables are usually provided with drainage connections, especially where freezing may occur. The inspector must make certain that any drainage facilities shown or specified are installed correctly and are free of stoppage.

BRIDGES

Highway and railroad bridges are required at numerous naval activities, either within the

activity or on access roads and connections adjacent to it. Points to be covered in inspecting bridge construction are given below. In addition to these check points, various inspection requirements given in other sections of this chapter may also apply, since bridge construction often may involve different types of work, such as pile driving, cofferdams, concrete, and so on.

CONSTRUCTION

In inspecting bridges, the inspector must avoid dictating construction methods or interfering with the choice of methods. He must, however, make sure that the methods assure satisfactory results and take steps to obtain their modification if they do not.

Inspectors must make sure that the plant is adequate, safe, and properly maintained. Special care must be taken to ascertain that erection travelers are adequately counterweighted to assure stability when lifting loads at maximum capacity and reach. If the erection scheme requires placing prefabricated spans by floating them to the site and lowering them into position by flooding the barge or barges, the inspector must satisfy himself that the floating equipment is stable during all stages of the operation and that flooding can be controlled accurately.

Many bridge projects require careful scheduling of the sequence of operations where interference with highway, railroad, or waterborne traffic is involved. In such cases the inspector must review in advance the schedule proposed, make sure that it meets the requirements of the project and the approval of his superior, and determine that it is followed when approved. If circumstances arise that necessitate modification of the schedule, his superior should be informed.

SPECIAL INSTRUCTION REQUIREMENTS

A basic requirement for inspection of the ACCURACY OF CONSTRUCTION is that the finished structure must be visually true. For example, curbs, and railings must be free of waviness, have true straight edges, and be uniform throughout. Defects are magnified because they are usually seen in foreshortened perspective. They can be avoided only by conscientious, competent workmanship, which is difficult to define exactly in specifications. Much depends on the capacity and intelligence of the inspector. He should have a clear understanding with the foreman or others concerned of the necessity for complying strictly with the basic intent of the specifications regarding quality of workmanship, and see that this intended quality is obtained. There are many other phases of the work on which special attention must be given to accuracy, some of which are more important to the structural integrity of the work.

On TIMBERWORK, for example, the inspector must make sure that members are cut square and to exact length so that they fit and bear fully without shimming. He must ascertain that bents are set truly vertical, that batter piles are on a uniform batter, that the tops of stringers are set truly in a level plane, that decking is of uniform thickness, and that guardrails are straight and uniform.

On CONCRETEWORK, the inspector must verify that forms are set exactly to the prescribed lines and dimensions and that they are free from waviness or other irregularities. He must make sure that the finished work conforms to these lines and dimensions. He must determine that reinforcement is spaced accurately and that the required cover over the steel is obtained. On highway bridges he must make sure that the specified crown or superelevation is maintained, and must require the use and adjustment of templates or finishing machines as necessary to obtain the results required.

Special attention must be paid to the accuracy of erection of STEELWORK to make sure that excessive drifting of holes is not needed in riveted work, that internal stresses are not introduced in welded work, that the specified camber is obtained, that girders and trusses are erected in a vertical plane without lateral distortion or side trust or tension from transverse members of inaccurate length, that secondary members fit without tension or slack, and that all joints make up without the need for springing members to make gage lines match.

Bridge piers located in the water may require caissons for construction. In addition, cutoffs of piles under water, placing of tremie seals, and cleaning of the bottom before construction of the piers is started must be carefully checked by the inspector. If circumstances arise that justify inspection by divers on any part of the work, the inspector should notify his superior so that arrangements can be made. The inspector should cooperate closely with the diver assigned, make sure that there is complete mutual understanding as to the specific conditions to be investigated and as to the conditions revealed by

the diver's inspection, and should supplement the diver's written report by his own independent report of the conditions reported.

DETAILS

Most major bridge piers are concrete structures supported on piles. Stone masonry facing may be used on important bridges for architectural effect or near the waterline on utilitarian bridges for protection from ice or other destructive actions. Steel or wrought-iron plates are also used for the latter purpose.

In underwater work, the inspector must make sure that any soft mud on the bottom is removed and replaced with acceptable material, if so specified, and that piles are driven accurately in the correct positions and to the penetration and bearing value prescribed and are cut off at the specified elevations. He must make sure that caissons or cofferdams are of the correct size, are accurately centered both longitudinally and transversely, and are plumb and watertight. If tremie seals are required, the inspector must make sure that the concrete meets all requirements; that tremie plant and methods assure placement of concrete within the mass of concrete, without permitting it to be dropped through water; and that the thickness of the tremie seal is the full thickness specified.

In the case of work performed in the dry, the inspector must make sure, when the caisson is unwatered, that the seal is tight and that the surface is cleaned and leveled if necessary. He must give particular attention to the quality of the concrete and the workmanship in placing it so as to assure dense, high-strength concrete free from honeycomb and having maximum durability under extreme conditions of exposure. He must make sure that any anchors required for securing masonry or armor are provided and firmly embedded as specified, and that the masonry or armor is correctly installed so that it can withstand the great forces that may be imposed on it by ice or debris. Special care must be taken to ascertain that the upper surfaces of piers are brought exactly to the required elevations and are finished to true plane.

The inspector must make sure that BENTS are accurately aligned and truly perpendicular to the longitudinal axis of the bridge. In many cases, templates will be necessary to assure accurate positioning of piles. The inspector must make certain that bridge seats are finished at the correct elevation and to the required plane or contour.

In addition to the general requirements for inspection of the concrete or other work involved, the inspector should check ABUTMENTS for settlement after fill has been placed against them. Settlement of approach embankments frequently occurs on soft ground because of the weight of the fill and induces settlement of the abutment. If settlement is detected, the inspector should inform his superior promptly.

The inspector must give special attention to the strength of FORMS and FALSEWORK and the adequacy of their SUPPORTS to make sure that displacement and settlement will not occur. If any appreciable movement takes place when concrete is placed, steps should be taken to remove the concrete before it has set.

Special care must be taken to determine that BEARING PLATES are of the materials and dimensions specified, and that they are set accurately and solidly. Plates for sliding expansion-joint bearings should be set so that the tool cuts are parallel to the direction of sliding. Rocker supports must be leveled and aligned so that each rocker participates fully in supporting the load throughout the full range of movement. The inspector must check their installation with great care and make certain that they are set at the proper position in their range to suit the temperature at the time of installation.

On highway bridges special care must be taken to obtain uniformly textured SURFACES with true lines and sharp edges for all exposed surfaces. The specifications may prescribe higher class finishes for surfaces visible from the bridge roadway. The inspector must make sure that the foreman or supervisor knows in advance which surfaces must have the higher class finish and see that it is furnished. The inspector must make sure that the roadway is crowned or pitched as specified.

The appearance of bridges is affected to a great degree by the quality of workmanship on the RAILINGS. In many cases, precast or prefabricated rails are specified to assure factory-grade precision, and designs provide for field adjustment to facilitate visually accurate alignment. In such cases, the inspector must check the rails on delivery for quality and workmanship and must also check the installation before the adjusting devices are sealed in to make sure that the rails have been correctly aligned. If cast-in-place railings are prescribed, the inspector must give special attention to the type, quality, and installation of the forms to make

sure that highly accurate railings are assured. Factory-made forms, usually of steel, are frequently used to obtain high-grade work.

EXPANSION JOINTS are required for practically all bridges. Frequently they are provided over every pier or over every other pier. On highway bridges special expansion combs are sometimes installed in the roadway slab to support the wheels across the joint and to reduce impact. Alternatively, the slab edges at the joint may be protected by steel angles, with or without sliding plates. The inspector must make sure that the devices provided conform to the requirements, are set truly perpendicular to the axis of the bridge, conform accurately to the contour of the roadway surface, and are rigidly anchored as required. Special care must be taken to make certain that the two matching members on either side of a joint fit each other in elevation and, if of interlocking-comb type, that the fingers fit into each other with balanced clearance in each side.

APPURTENANCES

Special care is necessary in inspecting the construction of bridge approaches to make sure that all the steps specified to minimize settlement have been taken. Otherwise, a depression may develop adjacent to the abutment that will give the highway or track unsatisfactory or even dangerous riding qualities. In some cases, a reinforced concrete transition slab may be specified to prevent this condition from developing. The inspector must determine that the transition slabs, if specified, are properly supported on the abutment, properly reinforced, and of full thickness.

Fenders will usually be required on either side of the channel span. They also may be required around other piers for protection from ice, debris, or collision. The inspector must make sure that they are strongly built. He should pay particular attention to the adequacy of all fastenings. Fenders are subjected to heavy impact and are designed to resist these blows in part by yielding and in part by spreading the force along the fender.

If lighting is specified, the inspector must make sure that conduits, ducts, handholes, and fixture outlets are installed progressively in the bridge structure. He must ascertain that lighting standards are rigidly fastened and are plumb and in alignment. He must make sure that all wiring is of the specified type, is carefully installed, and is tested for grounds and insulation resistance. He must make sure that the system is given an operation test and must check all features for compliance with requirements.

PAVEMENTS

Your duties may include the inspection of pavements, which may be constructed of various types of materials. Some of the factors to be considered in inspecting paving materials and operations are covered in the following sections.

SUBGRADE STABILIZATION

The specifications may, in some instances, provide that the subgrade be stabilized or given a higher density and bearing value than the natural earth on the roadway by mixing in selected earth of higher classification or other materials, such as rock screenings, ground limestone, or sand-clay. The inspector must ascertain that the added materials are of acceptable type, quality, and gradation conforming to the specifications, and that they are mixed and compacted in layers by the prescribed methods to develop the required density and bearing value.

BASE COURSES

In inspecting pavements the inspector will encounter various types of base courses. Some of the different types of base courses used and inspection requirements are discussed below.

Sand-Clay

Material in a sand-clay base course may be either natural sand-clay, or this material with sand or clay added to obtain better or more uniform qualities, or an artificial mixture of sand and clay. The inspector must perform such functions as assigned him in relation to inspection of borrowpits, sampling of material, designation of acceptable areas within the borrowpits, and shaping, draining, and finishing of borrowpits. Tests to determine satisfactory mixtures will usually be made by laboratory personnel.

Sand-clay mixtures are usually dumped on the subgrade; distributed uniformly to a loose thickness as directed; plowed, harrowed, and windrowed until a uniform mix is obtained; and shaped and compacted.

The inspector must determine that the material has the proper moisture content to produce the specified density; if not, he must require the water be added and uniformly mixed, or that the material be dried by harrowing and evaporation. He must make certain that the material is then promptly compacted, before its moisture content and consistency have changed, by rolling to the specified density. Rolling is generally accomplished first with a sheep'sfoot roller and then with a pneumatic-tired roller, followed by a motor patrol or grader. The inspector must make sure that all equipment is of specified or approved type and capacity. He must ensure that the final surface is true to line, grade, and contour, is free from ruts, and is uniformly of the specified density.

If further compaction by traffic is specified, the inspector must determine that the base course is subjected to properly distributed traffic for the specified minimum time and is maintained to the true surface and specified density until the wearing surface is laid.

Sand-Shell

In a sand-shell base course, the sand may be natural sand available at the site or imported sand from borrowpits. Shell is usually specified as dead reef oyster or clamshell. The inspector must make certain that both sand and shell conform to the specified requirements for quality and cleanliness and are supplied in the specified proportions.

Sand-shell base courses may be mixed on the roadway by spreading, plowing, harrowing, and disking; or may be mixed in a pugmill alongside the roadway and then spread. The inspector must make sure that the base course is uniform in proportion, is of sufficient loose depth to assure the full specified depth after compaction, is correctly shaped, and is at the optimum moisture content.

The inspector must ascertain that the material is compacted by rolling with sheep'sfoot rollers, pneumatic rollers, or other equipment as specified and that the final surface is true to line, grade, and cross section; is free from ruts or variation in texture; and is uniformly of the specified density or bearing value. Detailed requirements will either be fixed by the specifications or be determined by laboratory tests of materials.

The specifications may provide that the finished surface be tested by templates and that irregularities beyond a designated tolerance be corrected by scarifying and recompacting. The inspector must check the templates, usually one cut to the required crown for transverse tests and one straightedge for longitudinal tests, to make sure that they are accurate; check the pavement for compliance with the requirements; and require and oversee the correction of defective areas. Low spots caused by the raveling of a piece of shell during the final grading should be disregarded.

If further compaction by traffic is specified, here as with sand-clay base courses, the inspector must determine that the base course is subjected to properly distributed traffic for the specified minimum time, and is maintained to the true surface and specified density until the wearing surface is laid.

Soil-Cement

In the soil-cement type of base course, the soil is usually the native or selected material found in the roadbed. Cement is usually Type I portland cement.

The specifications usually require that the soil be scarified and pulverized to a prescribed fineness and maximum water content. The inspector must ensure that the necessary tests are made to determine that these requirements are met. It is essential to the successful performance of the work that the soil be in this condition when cement is applied. The soil must be shaped to the approximate cross section and the cement spread uniformly over the surface. The inspector must make certain that the cement is not applied during high winds unless it is drilled in so that it cannot be blown away, nor during cold weather unless the temperature is at least 40°F and rising. The inspector must make sure that the cement is immediately mixed uniformly with the loose soil for the full depth of treatment, but must determine that it is not mixed below this depth. He must make sure that a thorough, uniform, intimate mix of soil and cement is obtained and that the mixture is then reshaped to line and grade. He must check the moisture content of mixture and, if necessary, require the application and thorough distribution of additional water. The specifications will usually prescribe the optimum moisture and the tolerance allowed above or below this optimum. The inspector must ensure that the final moisture-density relations are satisfactory. The specification may permit plant mixing. The inspector must make sure that equipment conforms to the specifications, that accurate control of propor-

tions of materials and water is maintained, and that compaction is performed as a continuation of the mixing operation.

It is essential that compaction be completed before the cement has set. The inspector must make certain that the mixture is loosened and uniformly compacted to standard maximum density, as determined in the field by moisture-density tests on representative samples, and that the surface is reshaped to line, grade, and contour and then lightly scarified, moistened, and rerolled to true final line and grade. If work is not completed within the specified time limit after cement has been added, the inspector must require reconstruction of the section as prescribed.

Surface tests, made as described in the preceding paragraph, must be performed immediately and irregularities corrected as soon as possible, usually by scraping with a blade set for the lightest cut that will assure a surface true within allowable tolerances. The inspector must take cores or drill holes at the intervals specified and determine the thickness.

Immediately after the surface has been checked and found or made acceptable, the inspector must make certain that the finished base is protected and cured for the prescribed period by being covered with earth, straw, or hay and kept moist by being covered with cutback asphalt or by other methods, as provided by the specifications. He must make sure that all details of the curing process are faithfully performed as specified.

The inspector must make sure that traffic is not permitted on the soil-cement base until after the specified minimum time has elapsed, and then only as permitted and with the protection prescribed by the specifications.

Waterbound Macadam

In the waterbound macadam type of base course, the materials are generally crushed traprock, limestone, sandstone, lime rock, grave, chert, or similar locally available tough, abrasion- and weather-resistant stone. The inspector must ascertain that the rock conforms to requirement in physical properties, gradation, and freedom from deleterious substances.

Waterbound macadam base is generally constructed in one or more courses by spreading the rock to a uniform thickness, harrowing, wetting, and rolling. Stone screenings may be spread on the top course, wetted, and rolled in.

Rolling is accomplished by heavy three-wheel rollers. Specifications may prescribe compaction to a given percent of maximum density, or to a given stability by Marshall or other standard stability test. The inspector must ascertain that the specified compaction is obtained.

If surface and thickness tests are required, proceed as indicated earlier for sand-shell base courses, covering items as applicable.

Concrete

A concrete base course is seldom used except as a base for sheet asphalt surfaces on city streets. In such cases, it is sometimes built and finished as a concrete pavement. Infrequently, it is placed without expansion or construction joints, is finished to less exacting tolerances, and is given a relatively rough surface texture. The inspector must make sure that all applicable requirements for concrete pavements, as prescribed in the project specifications, are met.

Miscellaneous Base Courses

Various other types of base course may be encountered on projects at Navy activities, depending upon the materials available locally. The inspector must make sure that the materials used are prescribed or permitted by the specifications and meet all requirements as to physical properties, gradation, and cleanliness. He must make certain that the specified construction plant and methods are used; that the finished course conforms to requirements as to smoothness, uniformity, thickness, compaction, and density; and that any special provisions relative to curing, protection, and opening to traffic are complied with.

PRIME AND TACK COATS

A PRIME COAT is a treatment of bituminous material applied to the surface of a prepared base course to seal, waterproof, and bind the surface. Prime coats may be specified to be tar, rapid-curing or medium-curing cutback asphalt, emulsified asphalt, or asphalt cement. These materials are available in various grades, based on penetration, and are applied at rates of 0.1 to 0.3 gallon per square yard. The inspector should make sure that a prime coat is applied only where specified, that the material is of the type and grade specified or permitted, that the material is at a temperature within the upper and lower limits prescribed, and that

it is applied with a pressure distributor at the uniform rate specified or directed. If the inspector is made responsible for determining the rate per square yard, he must establish a rate, within the specified range, that will be sufficient to coat the surface thoroughly and uniformly without flowing off or forming standing pools. He should require a light, uniform application of sand, if specified, before permitting the base to be opened to traffic.

A TACK COAT is a light treatment of bituminous material, of the types and grades noted in the preceding paragraph applied over the prime coat or over old pavement immediately before the surface courses are placed. Rates are generally from 0.05 to 0.15 gallon per square yard. The inspector must make sure that, in addition to the procedures for inspection of prime coat, the tack coat is cured for a period long enough to permit it to dry but not so long that it loses its adhesive qualities, and that it is not covered with dust. No traffic should be permitted on a tack coat.

CONCRETE PAVEMENT

Portland-cement concrete pavement may be plain or reinforced, may be of uniform thickness or of thickened-edge type, and may be constructed with either Type I or Type III cement, with or without air entrainment.

The inspector should note that concrete for pavements is usually tested for flexure rather than compressive strength. He must ensure that flexure test specimens are prepared at the site in the number specified and delivered promptly, without damage, to the laboratory. The inspector must also make sure that expansion-joint materails, load-transfer devices, reinforcement, and other accessories conform strictly to the requirements, if not previously factory inspected.

On major paving jobs, the concrete is ordinarily mixed at the site in a paving mixer of the boom and bucket type and of not less than 1 cubic yard batch capacity, equipped with complete weighing, timing, and controlling devices. In some cases, aggregates and cement are preweighed and delivered in trucks equipped with batch boxes. The inspector must check all equipment; verify the accuracy and calibration of all scales, timers, and controls; and make sure that the equipment is operated in accordance with requirements, delivers concrete of uniform consistency in unsegregated condition, and distributes it uniformly on the subgrade.

After concrete is placed, it is struck off and compacted and finished mechanically with a power-driven machine, traveling on the side forms, until all voids are removed and the concrete thoroughly compacted and shaped to substantially the final contour. The inspector must ascertain that the finishing machine is in first-class working order, is operated by a skilled operator, and is adjusted so as to assure the required crown on the final finished surface, allowing for sag when spanning between the forms.

The inspector must make sure that all trucks handling aggregate are tight, that batch boxes when used are large enough to hold a full batch without spilling, and that cement containers are weathertight. If a central mixing plant is approved or the use of transit-mixed concrete is permitted, the inspector must determine that the subgrade is not adversely affected by the delivery of concrete, and must require correction of any rutting or other damage. He must make sure that the concrete as delivered is not segregated, and must reject concrete that has been mixed more than the maximum specified time.

Concrete pavement is placed between side forms, generally of steel channel shaped, of the same depth as the thickness of the pavement and with a broad base. Wood forms are usually permitted only on curves of small radius. The inspector must make sure that forms: (a) are of approved type, of proper depth and of specified weight, stiffness, and width of base; (b) are straight and true; (c) are accurately set to true line and grade; (d) are supported so that they are capable of sustaining without settlement the weight of the finishing machine or other equipment to be operated on them; and (e) are adequately joined, braced, and staked immovably in position. He must verify that forms are thoroughly cleaned and oiled before reuse.

Immediately before concrete is placed, the inspector must check the subgrade and make sure that it is true to line, grade, and contour and is uniformly compacted; that all defects have been corrected; and that it has been thoroughly moistened by watering the night before.

Placing of concrete on frozen subgrade must not be permitted. Mixing and placing of concrete is usually permitted when the air temperature is 35°F and rising, but prohibited when the air temperature is 40°F and falling. The limitations imposed by the specifications must be enforced. The inspector must make sure that concrete mixes conform to the approved design mix, are within the specified range of slump, have been

mixed for the specified minimum time at the prescribed rate, are uniform in quality, and are uniformly distributed. He must make certain that concrete is well spaded along forms and at joints. He should require placing of concrete to be stopped in time to allow finishing to be completed during daylight hours.

The inspector must give special attention to the installation of all joints. Transverse expansion, construction, and contraction joints will usually be required on all jobs. Longitudinal joints for similar purposes may also be required, but may differ in details. The inspector must make sure that the joints conform in type and location to those shown or specified and that they are installed accurately and solidly. Dowel bars must be oiled or painted as specified and must be set exactly normal to the joint. If expansion sleeves are required, the inspector must make certain that they fit accurately, allow the specified slip, and are tight enough to preclude entry of mortar. The inspector must give special attention to the assembly and support of load-transfer devices. If joints are required to be raked and filled with a poured filler, the inspector must make sure that the filler is of the specified type and proper consistency to fill the joint without flowing toward the gutter.

The attention paid to finishing operations affects greatly the appearance and acceptability of a concrete pavement. The inspector must make sure all surplus water, laitance, and inert material are worked off by scraping or squeegeeing with a straightedge of T section operated from parallel bridges resting on the side forms, or by a mechanical longitudinal float, working from the crown toward the gutter. Any pockets or marks caused by this scraping must be repaired by reworking the surface with hand floats. If required, the inspector must make sure that the surface is belted with a clean canvas or composition belt and checked with a straightedge, that variations exceeding the specified tolerances are corrected, and that the surface is given a final belting to produce a uniform texture. The inspector must make certain that all edges are rounded with an edging tool and that a strip of uniform width, generally 2 or 3 inches, adjacent to all joints is finished with a wood float, to assure that the surface on both sides of the joint is at the same grade.

The inspector must make sure that the concrete pavement is covered and cured for the full period specified, usually at least 72 hours, by one of the optional methods permitted by the specifications, such as ponding, and so on. If membrane waterproofing is used, the inspector must make sure that the full number of coats specified is applied, and that all bare or imperfectly coated spots are recoated. If freezing weather is anticipated, it may be necessary to require covering the fresh concrete with hay, straw, or grass to protect the surface from freezing.

The specifications usually prescribe a maximum acceptable variation from true grade of 1/8 inch measured as an ordinate from a 10-foot straightedge placed parallel to the centerline. If the pavement is crowned transversely, a crowned template may be required for checking deviations from the required contour. Specifications may require tests for pavement thickness, usually by cores taken at specified intervals. The inspector must keep an accurate record identifying the exact location of each core and giving its thickness. He must make sure that the holes left by corings are satisfactorily repaired and finished.

BITUMINOUS PAVEMENTS

Many types of bituminous pavement are widely used in various sections of the country. Among the principal types are hot-mix, hot-laid asphaltic concrete; cold-mix, cold-laid emulsified asphalt plant mix; cold-laid asphaltic plant mix; asphalt macadam; mixed-in-place macadam aggregate; mixed-in-place dense-graded aggregate; sand asphalt; and sheet asphalt. Many local variations are in common use, depending on economically available local materials, climate, and other considerations. These instructions for inspection are therefore general in nature. The inspector must familiarize himself with the detailed specifications for the project to which he is assigned and ascertain that the work is performed in strict accordance with the requirements.

CHAPTER 12

MAINTENANCE INSPECTOR

However well a structure is constructed initially, proper maintenance and repairs are necessary from time to time to keep it in first-class condition. An effective maintenance inspection will disclose whether specific types of maintenance or repairs are needed on buildings or other structures. In some instances, an inspection will turn up minor defects which can be corrected promptly and, as a result, prevent the occurrence of major defects requiring extensive repairs. As a Chief Builder, you may be called upon to conduct maintenance inspections at Navy activities. This is a responsible job and one that should be assigned to well qualified personnel.

This chapter points out different defects to look for when inspecting various parts of a building. We will also take up some of the major items that should be covered in maintenance inspections of other types of structures—including pavements, bridges and trestles, railroad trackage, and waterfront structures.

The types of structures that you inspect will depend upon the types available at your activity. So, consider those discussed here as typical of the many types that you will find at some activities. Let us emphasize, too, that this instruction is not intended to list every item that should be checked during an inspection of a specific type of structure. In addition to the items covered here, you may think of others, equally important, which should be given careful attention.

At some activities, forms may be available on which a check list is provided showing major items to be covered in the inspection of the structure concerned. These forms may be prepared locally, and therefore may differ from one activity to another. At times, of course, forms may not be available and the inspector will have to depend upon past experience in building and construction, as well as sound judgment, in determining what to look for in the inspection.

After completing an inspection, you may have to make a written report on your findings. You may also make recommendations on the type and extent of repairs needed to correct certain defects. You must remember that each inspection is important and should be done carefully, thoroughly, and with safety in mind.

INSPECTING BUILDINGS

There are many check points to be covered in a maintenance inspection of buildings, especially when the inspection extends from the basement up to and including the roof. We will not attempt here to cover all items that might involve a complete and thorough inspection of an entire building. We will, however, cover some of the primary items of concern to the inspector at Navy activities.

BUILT-UP FOUNDATIONS

The foundation of a building transfers the dead and live loads of the superstructure to soil that has enough bearing capacity to support the structure in a permanent, stable position. Footings are used under foundation components—such as columns and piers—to spread concentrated loads over enough soil area to bring unit pressures within allowable limits.

The foundation of a building should be inspected for stress and failure each year, and more often where climate, soil conditions, or changes in building occupancy-use present special problems.

Foundation Displacement

A foundation should be checked regularly for proper elevation and alignment. Complete failure in a foundation is rare; however, some settling or horizontal displacement may occur as shown in figure 12-1. Common causes of foundation

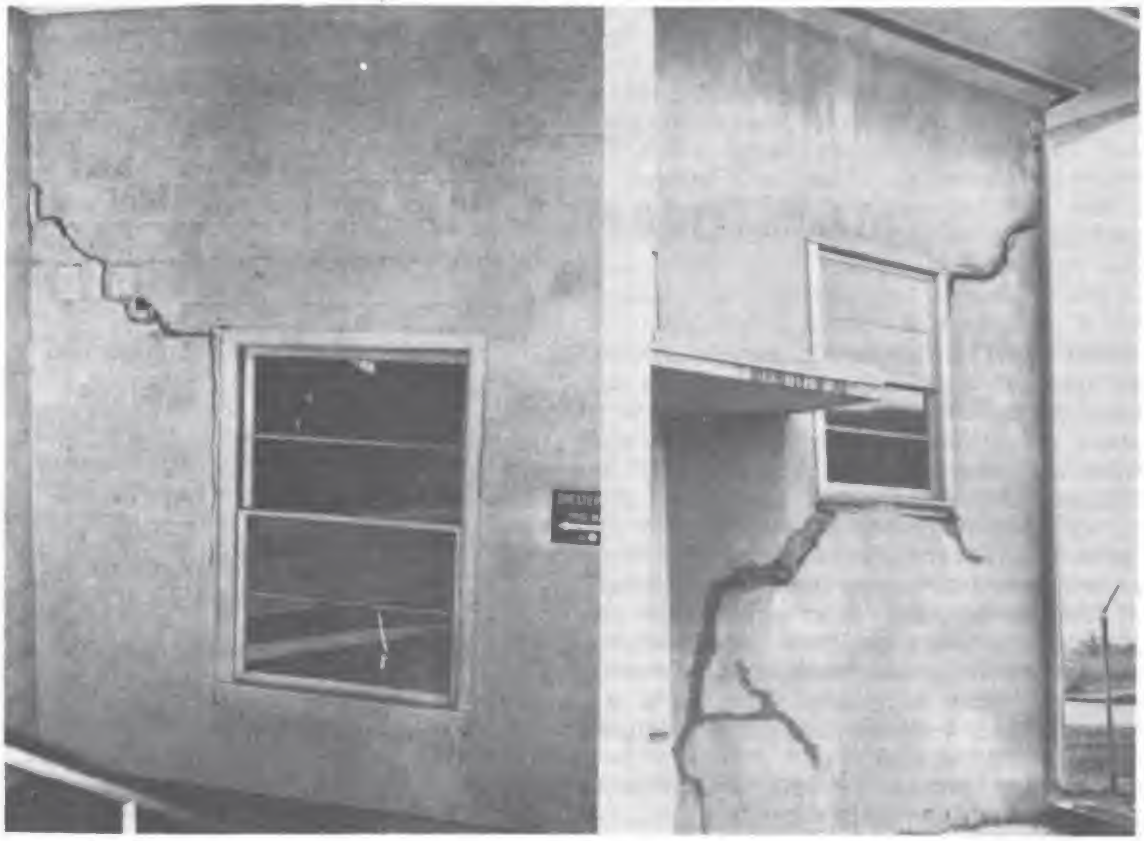


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Figure 12-1.—Signs of Foundation Displacement.

movement include: inadequate footings; overloading the structure; excessive ground water, which reduces the bearing capacity of soil; inadequate soil cover, which fails to protect against frost heaving; and adjacent excavations that allow unprotected bearing soil to shift from under foundations to the excavated area.

Severe, localized foundation displacement may show up in cracked walls, damaged framing connections, sloping floors, sticking doors, and even leakage through a displaced roof.

Material Deterioration

Foundations are subject to deterioration, whether from material or construction deficiencies or from environmental conditions. The deterioration of foundation materials must be observed directly unless the effects are severe enough to cause foundation settling. Excessive moisture from surface or subsurface sources is a major cause of timber deterioration. Untreated lumber is subject to wood decay, commonly called dry and/or wet rot. Wood decay is caused by wood-rotting fungi that grow in damp wood. Fungi attack wood members in contact with damp masonry foundations, moist ground or standing water, and water pipes that leak or on which moisture condenses. Poor ventilation around the wood hastens the process of decay.

Wood decay is indicated by:

- A damp, musty odor.
- Opening or crumbling of the wood.
- The presence of fine, dusty, reddish-brown powder under the building.
- A hollow sound when the timber is tapped.
- Easy penetration of timber by a sharp-pointed tool.

Concrete and masonry are subject to cracking, spalling, and settling, particularly under adverse ground and climate conditions.

Steel and other ferrous materials are subject to CORROSION in the presence of moisture, and sometimes by contact with acid-bearing soils. Signs of corrosion are darkening of the metal, rusting, and pitting.

CRAWL SPACES

Considerable deterioration extending from the foundation to the building superstructure can be caused by neglect of crawl spaces, especially in climates where it is necessary to enclose the space to maintain comfortable floor temperatures (see fig. 12-2). Unventilated crawl spaces contribute materially to rapid absorption of moisture into structural wood and other materials, and the spaces soon become a natural habitat for fungus growth and termites. Sills, joists, and subflooring may be affected by wood decay. Condensation may occur in the studding spaces above the floor level and cause paint failures.

Crawl spaces should be carefully checked periodically. In checking these spaces, ensure that they are clean, clear, and accessible. An accumulation of rubbish in the space may provide a natural harbor for insects and rodents, as well as impede access and possibly interfere with drainage. Scrap wood is a clear invitation to termites.

Look for disorganized storing of any material in crawl spaces. Also, check for accumulations of water that may breed mosquitoes, cause fungus growth, and weaken soil bearing under footings.

Ensure that all ventilation openings are covered with suitable hardware cloth or copper screening to prevent entry of birds and rodents. In addition, see that access doors to crawl spaces are provided with a suitable padlock and kept closed.

An inspection should include a check, where applicable, for termites. Wood and wood-and-masonry members are susceptible to termite attack. Subterranean termites become established in wood that is in contact with moist soil. Their

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Figure 12-2.—Damage Caused by Neglect of Crawl Space.

presence may be indicated by earthlike shelter tubes leading from the ground to the infested wood. Dry-wood termites live all their lives in dry, sound, and seasoned wood. A reliable sign of dry-wood termite attack is the finding of pellets in the immediate area.

FLOORS AND STAIRS

Floor materials found in shore establishment buildings and structures for various occupancies include wood, concrete, terrazzo, and clay tile. Common floor coverings include asphalt, vinyl tile, and linoleum.

WOOD floors should be checked quarterly for loose nails; warped, cupped, or loose boards; raised ends; slivers, cracks, loose knots, or raised nails; and water or other damage from improper cleaning, condensation, and wood decay.

CONCRETE floors should be inspected annually for dusting, spalling, cracking, and settling.

TERRAZZO floors should be inspected annually for loose or broken segments and damage from improper cleaning.

CLAY TILE floors should be inspected annually for missing, loose, or broken tiles; open joints; and damage from improper cleaning.

Floor coverings should also be inspected annually. ASPHALT and VINYL TILE coverings should be inspected for missing, loose, or broken tiles; open joints; serious indentations; burns; and damage from improper cleaning. LINOLEUM and other flexible coverings should be inspected for loose seams, buckling, serious indentations, and damage from improper cleaning.

Interior and exterior STAIRWAYS should be inspected at least quarterly for adequacy of support and safe condition of components. Stairways should be checked, as appropriate, for cracked, weathered, or rotted wood framing; for settled, cracked, or spalled concrete; and for rusted or loose metal supports or parts of loose nails on wood stairs. Treads should be inspected for loose or broken tread nosing; excessive wear; paint or tread covering deterioration; and loose, eroded, or slippery tread surfaces. Exterior treads should be sloped (or drilled) so as to drain properly. Handrails should be inspected for loose fastenings and material deterioration. Newel posts and balusters should be checked for looseness and missing parts.

EXTERIOR WALLS

Exterior walls fall into three structural categories: loadbearing walls (carrying structural loads); nonbearing walls (carrying only their own weight); and supported or enclosed walls, sometimes called curtain walls (with their weight supported by structural members).

Exterior walls are made of a wide variety of materials, including wood (shingles, weatherboard siding, plywood); concrete and masonry (brick, concrete or cinder block, reinforced or non-reinforced concrete, structural clay tile, stone, stucco); metal (corrugated iron or steel, aluminum, enamel-coated steel, protected metals); and mineral products (asbestos shingles, asbestos-cement sheets, and glass block).

Wood Exteriors

Wood exteriors should be regularly inspected for damage from wear, accidents, and the elements. They should also be inspected for damage resulting from insect pests. This may be done by tapping the wood with an object. A dull or hollow sound is an indication of damaged wood, which may be the result of insect pests. Painting and surface treatments should be inspected quarterly for deterioration; exteriors should be inspected for loose, warped, cracked, or broken boards or shingles.

Moisture is the most prevalent cause of failure of exterior walls. Stains, paint deterioration, and rot are usual signs of moisture damage. Condensation within and behind walls is a less obvious but equally damaging factor. Insufficient, loose, or displaced nailing produces separations and cracks that admit moisture and reduce the stability of wood walls.

Foundation settlement or displacement may cause misalignment of framing members and consequent damage to walls, including cracks in siding and breaking or displacement of boards or shingles.

Concrete and Masonry Exteriors

Concrete and masonry exteriors should be inspected quarterly for structural cracks, open mortar joints, settlement, efflorescence, stains and deterioration of paint or other surface covering.

Types of cracks encountered in brick, concrete block, and stone include horizontal movement cracks, vertical and diagonal movement cracks, and shrinkage cracks.

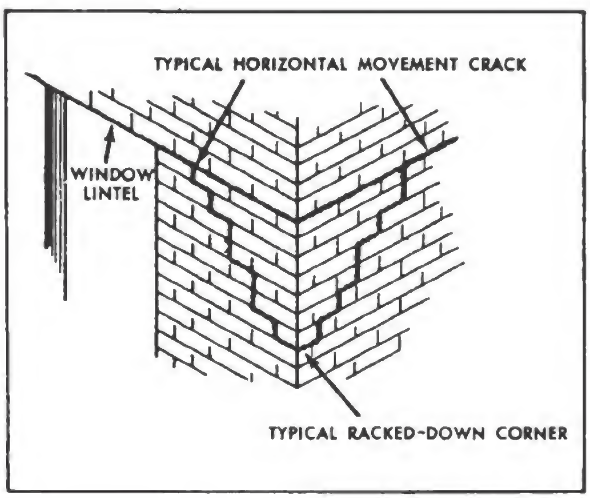
HORIZONTAL MOVEMENT CRACKS are usually long, wide cracks in the mortar joints that occur along the line of the floor or roof slab, or along the line of lintels over the window. Where these cracks turn the corner of a building, they frequently rack down, as discussed later. Observe figure 12-3, which illustrates a typical horizontal movement crack and racked-down corner.

VERTICAL AND DIAGONAL MOVEMENT CRACKS generally occur near the ends or offsets of buildings. They may also be found extending from a window sill to the lintel or a door or window on a lower floor. They vary from 1/8 to 3/8 of an inch in width and follow the mortar joints, but in some instances they may break through the bricks or other masonry. A diagonal movement crack is illustrated in figure 12-4.

SHRINKAGE CRACKS are the fine hairline cracks that are found in mortar as well as in concrete walls. The most noticeable ones are those running vertically, but a close examination of a section of wall that leaks may also show them in the horizontal or bed joints of brick or block walls.

RACKED-DOWN corners occur where the horizontal movement cracks along the side and end of a building meet. Frequently the horizontal crack not only continues around the corner but forms part of a diagonal crack that takes a downward direction and meets a similar crack from the other side, forming a V.

EFFLORESCENCE usually appears as a light powder or crystallization caused by water-soluble salts deposited as water evaporates within the mortar or the masonry unit. Aside from detracting from the appearance of a wall, efflorescence may indicate the penetration of moisture into the wall to an extent that could cause deterioration of interior wall coverings and finishes.



117.300
Figure 12-3.—Horizontal movement and racked-down corner.

117.301
Figure 12-4.—Diagonal movement crack.

INTERIOR WALLS AND CEILINGS

Interior walls are either plastered (wet wall) or covered with such materials as gypsum wallboard, plywood, tongue-and-groove wood paneling, tile or glazed-face masonry. Ceilings are usually plastered or covered with sheet metal or acoustical materials.

Some of the major defects to look for in inspecting specific types of interior walls and ceilings are indicated below.

Wood: checking; cracking; splintering; warping; sagging; breaks; support failure; rot; termite or other insect, or fungus infestation; and abrasions.

Soft Fiberboard (acoustical and insulation): open joints; buckling; sagging; support failure; failure of fastenings or adhesive; abrasion; breaks; holes; and stains from weather or utility leaks.

Wallboard, Plasterboard, Hard Pressed Fiberboard, and Cement-Asbestos Board: open joints; cracking; buckling; sagging; support failure; failure of nailing or adhesive; abrasions;

breaks; holes; and discoloration or decomposition from weather or utility leaks.

Plaster: cracking; buckling; sagging; support failure; spalling; crumbling or falling from moisture absorption; peeling, or flaking from moisture or sealer failure; and discoloration from weather or utility leaks.

Ceramic Tile: chipping; cracking; loose or missing tile; holes; defective mortar joints; and etched, pitted or dull surface caused by use of acidulous or abrasive cleaners. Also, make a careful check for cracks and defective calking around baths, showers, and sinks, where water leaks could cause damage to other rooms, floors, and so on.

Metal: corrosion, rust, abrasion, indentations, punctures, and deterioration of protective coating. In addition, look for sharp edges, splinters, corners, etc., which could cause injuries or material damage.

DOORS

Exterior doors are more subject to abuse and to weathering than interior doors. In general, though, defects encountered in inspecting both exterior and interior doors are similar.

Doors should be inspected quarterly for the following defects, where applicable: poor fitting, including deteriorated or damaged frames; paint deterioration; material damage, such as cracked or broken glass, split or cracked wood panels, warped or dented metal, and warped or broken screening; and broken or inoperative hardware, such as locks, hinges, and slides. In addition, check all door stops, thresholds and weatherstripping for cracks, looseness and workability, where applicable.

Mechanical injury to mullion, headers, jambs, or hardware usually causes trouble with LARGE WOOD FRAMED AND BRACED DOORS. Decay, resulting from exposure to weather or shrinkage of door members, also causes distortion or failure. Frequently, the free edge of the door sags and causes the door to bind at the bottom and open at the top. In inspecting these doors, the following checks should be made:

- Examine the jamb opening to see that the hinge and lock sides are plumb and parallel.
- Check the doorhead to see that it is level.
- Check anchorage of the jamb and the hinges.
- Check lock face plates for projection beyond the face of the door.
- Check all members for swelling, shrinking, or warping.

Failures in PANEL DOORS are similar to those in large wood doors. In addition, panel doors are subject to binding at the hinge edge, as well as friction between the dead bolt and strike plate or between the latch bolt and strike plate.

METAL doors, commonly used in warehouses, hangars, stockrooms, galleys, and other areas where hard service or other operations require them, are of various types: metal clad, hollow metal, and solid metal, with variations including interchangeable glass and screen panels.

When inspecting metal doors and fittings, carefully check the screens, nuts and bolts, special fasteners and operating devices to ensure they are tight and in good order. See that frames are plumb and corners square so that the door fits its opening with proper clearances. Check weatherproofing and calking to ensure they are maintained in a workmanlike manner. See that service doors in galleys, stockrooms, and other areas where personnel pass in and out frequently with arms loaded are provided with kickplates and with bumper protection to prevent slamming against walls.

WINDOWS

Both wood and metal windows are found in structures at Navy activities, and the inspector should be alert to detect any defects present in either type.

In an inspection of wood windows, the inspector should look for loss of putty; deterioration of paint; rotting of wood members; binding of parting or stop beads; windows forced out of shape by settling, shrinking, or twisting of the building frame; swollen or improperly fitted sash; broken or unequal length sash balances; and sash stuck with paint to the stops or jambs, or at the meeting rails.

In an inspection of metal windows, the inspector should inspect for rusting, warping, and sticking of operating devices. He should also ensure that calking is maintained in good order to prevent leakage of moisture and air.

ROOFING

In inspecting structures, you will probably inspect different types of roofing, such as built-

up, asphalt-shingle, roll-roofing, and so on. The inspection of roofs may require the use of portable ladders where no other means of access is available. During an inspection, DO NOT walk directly on slate, cement-asbestos, asphalt-roll, or asphalt-shingle roofs; use ladders or cleated boards to distribute your weight.

The roof of structures should be inspected semiannually. Various defects to inspect for, among the different types and areas of the roof, are indicated below:

Wood-Shingles: wear from weathering; warped, broken or split shingles; excessive curling; missing shingles; and flashing failures.

Tile: wear from weathering, broken, cracked, loose, or missing tiles; flashing failures; and deterioration of expansion-joint material or tile raising from improper placing or inadequate expansion joints.

Slate: wear from weathering; broken, cracked, loose, or missing slate; and flashing failures.

Metal: holes, looseness, punctures, broken seams, inadequate side and end laps, inadequate expansion joints, rust or corrosion, and damage resulting from contact of dissimilar metals.

Cement-Asbestos: wear from weathering, broken, cracked, loose, or missing laps; and insufficient side or end lap.

Asphalt-Roll: weathering, cracking, alligatoring, buckling, blistering, insufficient or uncemented laps, tearing from nails too close to edge, and other damage to coatings.

Asphalt-Shingle: lifting, weathering, cracking, curling, buckling, blistering, loss of granules, and excessive exposure.

Built-Up: cracking, alligatoring, low spots and water ponding; failure or lack of gravel stops; cracks in membrane; exposed bituminous coatings; exposed, disintegrated, blistered, curled, or buckled felts.

Fastenings: loose, missing, or broken fasteners; defective fasteners; and exposure.

Metal Base Flashings: rust; open vertical joints; loose flanges; inadequate or exposed nailing; improper fastening; improper sealing with felt strips; and deteriorated or missing cant strips.

Other Base Flashings: sagging, separation, inadequate coverage or embedment, open vertical joints, improper fastening, buckling, cracking, surface coat disintegration, and deteriorated or missing cant strips.

Metal Cap Flashings: rust, corrosion, open joints, and loose or improper fastenings.

Other Cap Flashings: open joints, buckling, cracking, surface coat disintegration, and improper fastenings.

Chimney, Wall, Ridge, Vent, Valley and Edge Flashings: open joints and loose or improper fastenings.

PAINT

All painted areas should be inspected annually. Defects to look for in the inspection include: alligatoring, checking, blistering, crawling, cracking, scaling, peeling, wrinkling, flaking, fading, loss of gloss, excessive chalking, mildew, bleeding, staining caused by insect screens or splashing, discoloration, and complete absence of paint.

It is assumed that, through study and experience, you are familiar with the types of defects mentioned above and can readily identify them. Therefore, the defects are not described here.

WATERFRONT STRUCTURES

Inspection should be made annually of all basic waterfront structures (piers, wharves, quaywalls, bulkheads, retaining walls) and semiannually for fenders and movable equipment such as brows and camels. More frequent inspection may be necessary under certain circumstances, such as tidal waves, high tides, earthquakes, and action by destructive forces of nature. Inspections may be made from the structures, from a boat or afloat. Cameras are sometimes used as an aid in visual inspection.

Listed below are various items that should be covered in an inspection of waterfront structures, and defects to look for in inspecting these items.

Curbing, Handrails, and Catwalk: loose, missing or broken individual sections; uneven surfaces, obstructions, and other hazardous conditions.

Bollards, Bits, Cleats, and Capstans: breakage; excessive wear; rough or sharp surfaces and edges detrimental to handling lines; and missing, loose, or defective bolts.

Deck Drains and Scuppers: loose, missing, or broken screws; and water ponding indicating clogged drains or need of deckfill or other repair.

Manhole Covers and Gratings: rust, corrosion, mechanical damage, and bent or worn hinge pins.

Asphalt Deck Covering: cracks, weathering, holes, shoring, rutting, and porous surfaces.

Ladders: rust; corrosion; loose, missing, twisted, bowed, bent, or broken steel members; loose, missing, cracked, split, rotted, or broken wooden members; and defective supports and anchorage.

Deck Planking: worn, loose, missing, cracked, broken, or splintered planks; deep abrasions; decayed planks; and termite or other pest infestation, particularly on underside surfaces.

Wood Stringers and Pile Caps: loose, missing, or broken stringers or caps; termite and other pest infestation; crushing of wood fiber, particularly at bearing points; and ineffective bearing area not in contact with bearing piles.

Wood Bearing Piles: displacement; missing or broken section; porosity of surface; and pest infestation and decay, particularly at top and areas within tide range. Areas subject to marine borers will require inspection by divers for signs of entry. Pronounced attacks will necessitate removal of several piles for sectionalizing, and extent of damage will constitute a representative sample, and condition of other piles may then be ascertained.

Wood Fender Piles: loose, missing, cracked, or broken piles; excessive wear; mechanical damage; termite and other pest infestation; wrappings for broken, loose, or missing cables and fastenings; and loose or missing wedges.

Wood Bracings, Wales, and Chocks: loose, missing, broken, split, warped, or decayed bracings; rotted bolt holes; and termite or other pest infestation.

Fire Walls: structural damage, general deterioration, and lack of airtightness.

Embankment Slopes and Areas Behind Walls: erosion, settlement, or slippage resulting from improper drainage; lack of full sod or vegetation coverage; damage from burrowing animals; and slopes steeper than angle of repose.

Steel Deck Plates, Gratings, and Their Supports: rust; corrosion; and loose, missing, broken or bent supporters.

Steel Beams, Girders, and Piling: rust, corrosion, structural damage, misalignment, and defective connections.

Steel Tie and Rod Bracings, Long Bolts, and Wales: rust, corrosion, broken or bent bracings, loose nuts and anchor plates, lack of tautness, failure or missing wrappings on tie rods, and defective connections.

The inspector should report for replacement or repair individual steel members when deterioration has reduced flange or web thickness by:

- 50% or more for rods and long bolts.
- 40% or more for bracings and wales.
- 30% or more for all other members.

Grounding Connections: loose or missing connectors, rust, corrosion, and mechanical damaged connectors.

Connections: rust; corrosion; and loose, missing, or broken connections.

The inspector should report steel for cleaning and painting where surface area is corroded:

- 50% or more on deck plates, piles, bracings and wales.
- 40% or more on individual beams and girders.

Concrete Slabs: general deterioration, breakage, cracking, and spalling, particularly at bottom surfaces; reinforcing steel for exposure, rust, or corrosion; and expansion joints for loose or missing filler. Report reinforcing for repair when broken or when cross section is reduced 40% or more.

Concrete Foundations: cracking; breakage; scouring; spalling; exposed reinforcing; and evidence of movement, settlement, and undermining.

Concrete or Masonry Walls: cracking, spalling, general deterioration, exposed reinforcing, sandy mortar joints, bulging, and vertical and horizontal misalignment.

Concrete Beams and Girders: breakage; cracking; spalling, particularly at edges; rust; corrosion; and reinforcing steel for exposure.

Concrete Piles: breakage; cracking; spalling, particularly within areas of tide range; rust; corrosion; and reinforcing steel for exposure.

Bulkheads: loss of section, excessive weathering, loss or settlement of backfill, and erosion of bottom. Check depths of water adjacent to bulkhead for comparison with original depths.

Bulkhead Tie-Rods: loose or missing connections and corrosion.

Protective Coated Areas: rust, corrosion, deteriorated coating, and complete loss of coating.

Many steel waterfront structures have cathodic protection systems installed to control corrosion caused by galvanic corrosion or electrolysis.

Although the Builder is not expected to be technically capable of maintaining or inspecting these systems, he may, as Chief Inspector, be responsible for directing a program covering their inspection. If you are assigned this task, you will want to refer to NAVFAC publications for information that will aid you in developing an inspection program.

PAVEMENTS

Paved areas such as airfields, roads, walks, and parking areas may have various defects. These areas should be inspected quarterly or more often when the temperature drops well below freezing; after operational accidents; after heavy rains; and in periods of extremely hot weather.

Various defects to look for when inspecting concrete flexible-type pavements are indicated below.

Expansion Joints: not vertical, slot above expansion joint filler not directly above filler; filler missing, unbonded, or extruded; dirt, sand, stone, or foreign material wedged in joint.

Joints: pumping evidenced by soil particles and water forced upward through joint, spalling caused by inadequate expansion joints or faulty construction, or both.

Cracks: transverse cracks near doweled joints tend to be caused by poor dowel alignment. Interior corner cracking is indicative of poor subbase support or overloading. Longitudinal cracks are caused by improper joint spacing, inferior coarse aggregate in the concrete mix, or poor subgrade support and overloading. Radial cracks from a point are caused by overloading and/or "mushroom" earth support. Prismatic sections of pavements, bounded by cracks, are also developed by overloading and irregular nonuniform support. Cracks that crisscross, and are extensive, are caused by extensive overloading. "Cracked-out" sections that are pushed downward are usually caused by soft, wet subgrades covered with inadequate subbase. Such cracked-out sections may also be caused by nonuniform subsidence of the paved area. Corner or outer-edge cracking is caused by passage of moving loads from pavement to shoulder and back again.

Depressions: caused by consolidation of soft soil under load. Such depressions may be evidenced by ponding of water after rains.

Scaling: usually caused by overfinishing which produces concrete with an excess of cement in the pavement surface. Sometimes scaling is caused by chemicals used to remove snow and ice.

Abrasion: caused by blading equipment to remove snow and ice or to grade and reshape shoulders.

Buckling: caused when the pavement is restrained from expanding.

Frost Heave: caused by expansion of a wet subgrade when it freezes.

Groving and Shoving: caused by high pressure tires operating on surfaces of inadequate stability.

Raveling: aggregate particles pulling loose from surfacing.

Burned Areas: caused by heat effects from blasts of jet aircraft. (Surfacings become lifeless and brittle, and separated aggregate may be blown about by blast.)

Softening: caused by spillage of petroleum distillates or jet plane blasts.

BRIDGES AND TRESTLES

Bridges and trestles constructed of steel, timber, masonry, concrete, and composite materials have quite a number of check points that should be inspected annually. Major check points that should be covered in the inspection, and defects to look for, are listed below.

Side Slopes: failure to maintain slopes of 1-1/2 to 1 or more, inadequately protected with vegetation or mulch, concrete overlays (if applicable), cracking, spalling, and broken areas.

Bridge and Foundation Protective Structures, such as Riprap Cribbing, Bulkheads, Dolphins and Piles: missing or broken piles, insect and other pest infestation, decay, erosion, undermining, and scouring.

Drainage Ditches: loose bottom and sides, improper side sloping, silting, and failure to protect surrounding areas at outfalls from erosion.

Roadway of Approaches: cracked, broken, corrugated, and disintegrated concrete or bituminous surfaces; cracks, breakage, or other damage to curb and gutter sections.

Approach Fill: settlement, particularly at joint between fill and structure.

Fences, Barricades, and Railings at Approaches: inadequacy or structural damage; and missing or illegible load and speed limit signs.

Drainage Channels: erosion; scouring; accumulations of driftwood and debris above, below,

and at structure; and evidence of possible course diversion resulting from obstructions and erosion.

Concrete Foundations: cracks, scaling, disintegration, exposed reinforcing, scouring, undermining and settlement.

Abutments and Piers: cracks; breaks; scaling; spalling; disintegration; open joints; evidence of damage from impact and vibration; failure of expansion devices; and damage from floating debris, ice, and waterborne traffic.

Timber Framing: loose, missing, twisted, bowed, split, checked and unsound members; deteriorated joints; rot; and termite or other insect infestation.

Steel Framing: rust; corrosion; and loose, missing, bowed, bent, or broken members.

Concrete and Masonry Structures: weathering, crackings, spalling, exposed reinforcing, sandy mortar joints, and broken or missing stones.

All Superstructures: damage from floating debris, ice, and waterborne traffic; and misalignment, both horizontal and vertical.

Wood Flooring: loose, missing, broken or rotted pieces; protruding nails and other fastenings.

Structure Roadways: cracked, broken, corrugated, or disintegrated concrete or bituminous surfaces.

Concrete Curbs and Gutters and/or Concrete or Masonry Handrails and Handrail Walls: loose, missing, or broken individual sections; misalignment; sandy and eroded mortar joints; and loose or missing capstones.

Expansion Joints: improper sealing; loose or missing filler; and failure to allow movement due to trash or debris.

Metal Handrails: rust; corrosion; looseness; and missing, broken, or misaligned handrails.

Bridge Seats, Bearing and Cover Plates: rust, corrosion, and missing or loose plates.

Rollers and Other Similar Devices: rust, corrosion, inadequate lubrication, and failure to allow movement.

Cables: frayed, raveled, or broken strands; inadequate lubrication; defective anchorage; and interference from overhanding objects.

Splices, Bolts, Rivets, Screws, and Other Connections: rust; corrosion; and loose, missing or broken welds.

RAILROAD TRACKAGE

At activities where railroads are used, you may have the job of inspecting the trackage. Check points that should be covered in the inspection, and defects to look for, are indicated below.

Tracks: vertical and horizontal misalignment caused by heaving, sinking, churning, inadequate expansion, and rough spots.

Rails: breaks; splits; cracks in head, web, or base; damage from flat wheels; creeping or shoring, particularly at curves; and battering, overflow, or chipping of obstructed flangeways or girder-type rails.

Joints: loose angle or splice bars, loose or missing bolts, and inadequate expansion.

Spikes: loose or inadequate number per tie, and improper tie-plate seating.

Road Crossings: poor condition, roughness to traffic, and obstructions.

Ties: decay, splitting, general deterioration, rail cutting, and insufficient or improper embedment in ballast.

Ballast: dirt and mud accumulations, soft or wet spots, grass or weeds, washing away and settlement, inadequate extension beyond ties, slope to grade greater than 1-1/2 to 1.

Drainage: obstructed drainage ditches and culverts; erosion of side slopes and shoulders of ditches and roadbed; slides or potential slides close to track; and erosion at head-walls, inlets, and discharge openings.

Turnouts: lack of lubrication; clogged with debris or dirt; inadequately spiked; out of gage; and improper operation of switch, switch latches, targets and lamps.

Protective Devices: signs missing or damaged, illegible or poor structural stability; guardrails in poor structural condition; and presence of weeds or other obstructions around warning signs.

Utility Lines: corrosion, sagging, loose or missing supports, and damaged poles.

CHAPTER 13

THE COMPANY CHIEF

The senior enlisted man in the company may be assigned the duties as Company Chief. In this capacity, he will serve as the principal enlisted assistant to the Company Commander.

It is not possible to cover completely the areas of responsibility of the Company Chief in this manual. This chapter will, however, serve as a guide for the Company Chief in the performance of his duties in regards to supervision and management of projects, personnel, administration, training, and military functions.

As the senior enlisted man of the company the Company Chief usually possesses sufficient training and schooling to act as principal enlisted assistant in all administrative, technical, and tactical matters of the company. He also has developed those qualities of leadership which tend to elicit from subordinates unquestioned cooperation, loyalty, and obedience under any circumstances or situations.

The success the company achieves will depend upon the degree of coordination and cooperation developed within the company. To effectively reach these goals the Company Chief must meet additional requirements in the management field. He must maintain initiative and use sound judgment in the guidance of human resources to attain the objectives of good management. He must have the faculty for working in harmony with officers and other petty officers. He must be able to communicate ideas effectively (orally and in writing) at all levels. He must possess a comprehensive understanding of Navy organization, the mission of the battalion, and the working organization at the company level.

PROJECT MANAGEMENT

The productivity on the company projects will depend upon such factors as the level of training of personnel, teamwork, condition and availability of equipment, and status of material. The effective Company Chief will recognize where problems in these areas exist or may develop and will take corrective action before production or working relations are affected. His actions or decisions should be based on knowledge and information available. Keep in mind that the more complete this knowledge and information, the better the quality of the actions or decisions and, therefore, the chances of success.

Little will be accomplished in the company unless responsibilities are specified for all levels of supervision. It is one of the duties of the Company Chief to ensure that areas of responsibility and level of authority are clearly defined for each enlisted man in the company.

The Company Chief should establish good communications with the Platoon Leaders and Company Commander in matters pertaining to the efficient operation and effective working relations of the company. He should make frequent inspections of all company projects to ensure that good working practices are employed and that manpower, equipment, and materials are being properly utilized. The Company Chief will report the results of these inspections to the Company Commander, including the status of all matters pertaining to the projects. He will also make recommendations, if needed, that will improve working conditions or efficiency, as well as assist the Company Commander in maintaining good working relations with other companies.

MILITARY DUTIES

The Company Chief will assist in ceremonies, briefings, conferences and other functions as designated by the Company Commander. He will assist in the assignment of personnel to weapons and positions in the company military organization. He will study the battalion defensive plans, assist in the laying out, and coordinate the construction of company defensive positions.

He will help ensure the readiness of the company by assisting the Company Commander in the inspection of company material, equipment, and personnel.

BATTALION TRAINING

Most training for the company will be administered through the battalion organization, with the Training Officer administering the training programs under the direction of the S-2 officer. To develop the necessary construction-combat skills within the battalion, the Training Officer will utilize training facilities such as service schools, fleet schools, civilian schools, disaster recovery training units, and military training units, as well as battalion formulated training programs. It is important that the Company Chief assist the Company Commander with contact of S-2 personnel and coordinate the assignment of company personnel to training designed to establish the company capability at the required level.

PERSONNEL READINESS CAPABILITY PROGRAM

The Commander, Naval Construction Battalions, Atlantic/Pacific Fleet (CB LANT/PAC) has established the manpower skill level capability requirements for each Mobile Construction Battalion (MCB). The difference between the desired and actual capability is the training requirements in terms of skills and levels of proficiency. To assist in determining the state of readiness and capability of a Seabee unit at any time, and to plan for training and personnel support, the Personnel Readiness Capability Program (PRCP) was developed. The PRCP will answer such basic questions as how many Builders can finish concrete, and how many of these will complete the next deployment? Using the information gathered through the PRCP system, a training plan is formulated to ensure that the unit is fully able to perform the capabilities required during the next deployment.

The data on skills of each member of the command is gathered by units in the field and recorded on an 8" x 10-1/2" keysort card. Information concerning personal data (rate, service number, etc.), crew, individual, military and special skills is encoded on the card by punching slots in the edges of the card. This information is retrieved by a manual sorting machine. The data is retained by the unit and also transmitted to CB LANT/PAC. Any desired information can be selected in the field. Thus, if the Operations Officer needs a list of all the Steelworkers that are certified weldors a complete list is rapidly provided.

COMPANY TRAINING

The primary objective of the battalion administered training program is the overall readiness of the battalion. Responsibility for the education, training, and resultant progress of each individual in the company remains with the Company Commander. The Training Officer may also direct that certain training functions be at the company level and that such programs be administered by the company. Therefore, the Company Chief has the responsibility to assist the Company Commander in an effective training program and to keep check on the progress of company personnel.

The enlisted advancement system is based upon providing adequate training for enlisted personnel. Although selected individuals receive training in service schools, it is neither intended nor desired that formal schooling provide the entire training needs for any rating. The continued effectiveness of the advancement system, therefore, depends on the in-service training and support provided by individual commands. Responsibility for this training, in a MCB, rests with the Company Commander.

Objectives of the company program should include (1) developing in each candidate for advancement the skills necessary for the rating to which he aspires, (2) imparting the knowledge related to these skills, (3) developing petty officer attributes with emphasis on the quality of leadership, and (4) providing items that contribute to the overall efficiency of the company (safety instructions, new work methods, and so on).

The Company Commander has five major functions in the enlisted advancement system: (1) to encourage all his personnel to quality for advancement; (2) to give exact information on requirements for advancement, available schools, and eligibility requirements for these schools; (3) to recommend for advancement in rating those who have met the qualifications; (4) to establish procedures for training and advancement, and (5) to maintain an effective training program.

The Company Commander normally outlines the course of instruction applicable to the com-

pany and delegates the responsibility for instruction, record keeping, and the frequent checking on individual progress in completing study assignments and practical factors.

ORGANIZATION

The content, timing and organization of the company training program will depend on such factors as location, operational commitments and experience of the company petty officers, training aids and training facilities available, and requirements of higher authority. Therefore, the training program will have to be tailored to meet the requirements of each company.

The following example may be useful as a guide for delegating responsibility for a training program. Delta Company, MCB 901, is organized with three platoons. The first platoon consists of a Chief Builder as Platoon Leader, with rated Builders and Builder strikers. The second platoon consists of a Chief Builder as Platoon Leader, with two squads of rated Builders and Builder strikers and one squad of Steelworkers and Steelworkers strikers. The third platoon consists of a Chief Steelworker as Platoon Leader, with rated Steelworkers and Steelworker strikers. The training responsibilities for the company may be organized as follows:

1. The Platoon Leader (BUC) of the first platoon may be responsible for the developing of skills and knowledge of the Builder rating for all Builders in the company. Using the petty officers of his platoon as instructors, he may direct a training program that is designed to (1) prepare Builders at all levels for advancement (including practical factors), (2) improve working practices or efficiency of the Builders, and (3) prepare the Builders for any upcoming projects. The Platoon Leader may turn in reports of instructions and progress to the company clerk.

2. The Platoon Leader (BUC) of the second platoon may be responsible for the leadership program, instructor training, and safety training of the company. He may direct a training program that is designed to (1) develop leadership, (2) provide qualified instructors for the company, and (3) ensure safe working practices. Due to the nature of subjects the Platoon Leader may call on various qualified petty officers in the company to serve as instructors for his training program. He may turn in reports of instructions and progress to the company clerk.

3. The Platoon Leader (SWC) of the third platoon may be responsible for the developing of skills and knowledge of the Steelworker rating for all Steelworkers in the company. Using the petty officers of his platoon as instructors, he may direct a training program that is designed to (1) prepare Steelworkers at all levels for advancement (including practical factors), (2) improve working practices or efficiency of the Steelworkers, and (3) prepare the Steelworkers for any upcoming projects. The Platoon Leader may turn in reports of instructions and progress to the company clerk.

4. The company clerk may collect training information from the Platoon Leaders and prepare company records and reports. The company records may be designed to include (1) each individual's progress toward advancement, (2) each skill in which an individual has received instruction, and (3) any other information deemed necessary by the Company Commander.

5. The Company Chief is responsible for the preparation of training schedules; assisting the platoon leaders in such matters as obtaining training publications, training aids, and training facilities; assisting the Company Commander in the review of lesson plans, records, reports and in the evaluation of the training program.

6. The Company Commander normally will direct the company in ground defense and passive defense exercises; organize and direct the training program of the company; assist in formulating MCB training at meetings with the Executive Officer; review each individual's progress toward advancement; evaluate the effectiveness of the company training program; and review and sign company training reports that are submitted to S-2, S-3, and so on.

INSTRUCTORS

The petty officers of the company will be the instructors in the company training program. Although teaching ability is included among the military requirements for enlisted personnel in pay grades E-5 and above, most of the petty officers will have little experience as instructors. Ability and knowledge in a particular field does not automatically enable a person to impart that ability and knowledge to others. Few petty officers will be able to teach effectively without some training. Therefore, in the company training program the development of instructors should be one of the primary objectives.

Chances are that several of the senior petty officers of the company have had a tour of

instructor duty, and will be good instructors for the instructor training program. The Manual for Navy Instructors, NavPers 16103 (current edition), is the basic text for use in instructor training.

ON-THE-JOB TRAINING

There are several different methods for conducting supervised training. However, because on-the-job training is the most effective method for teaching the skills and knowledges of the building trades, it is the only method covered in this chapter.

There are many forms of on-the-job training. It may be in the form of an especially tailored, well-organized program, such as one designed to help plumbers acquire advanced skills in plumbing. Then again, on-the-job training may be in the form of simple instruction, like explaining and showing a man how to replace a washer on a leaky faucet. In other words, when one man helps another learn to do a job and makes sure he learns the right way, it is a form of on-the-job training. Therefore, the term ON-THE-JOB TRAINING has come to mean "helping an individual acquire the necessary knowledge, skill, and habits to perform a specific job." This implies that on-the-job training applies not only to the new men in an organization, but also to any person who is assigned a new job. No person should be regarded as completely trained, and on-the-job training is a continuous function in the Seabees. Performance can always be improved by keeping interest high and by passing on directions, suggestions, and information which may increase proficiency. The process of on-the-job training requires active supervisors who are aware of the needs of the trainees and who can motivate them to learn.

Most of the projects available for on-the-job training will be the construction projects assigned to the company. The methods of utilizing these projects for training will be the responsibility of the Company Commander.

In setting up an on-the-job training program the mission of the unit is paramount. However, careful consideration should be given to the individual trainee's progress. The requirements for the individual's advancement in rating should also be a factor in determining the types and levels of training.

In determining training needs, it is often a good idea to interview the trainee. A summary of previously acquired skills and knowledge relative to the job he is to do can be obtained by questioning (this information is recorded on the PRCP cards). Compare jobs the trainee knows how to do with those he will be doing. Determine the training needs (required knowledge and skills minus knowledge and skills already possessed). Interview the crew leader who will supervise the job and actually conduct the training. It is important that the trainer and trainee understand the objectives at which the training is aimed and that the purpose of the training be explained. The long range training program of the company must be closely coordinated. When an electrician is moved from a line crew and assigned to an internal wiring crew for training, the move must be explained to everyone concerned.

Effective training requires a great deal of planning and directed effort, organization of materials into logical sequence to prevent a haphazard approach to the job of training, and accurate measuring methods for evaluating results. In the Seabees, most on-the-job training results in a finished product which makes evaluation of the training easy. Keep in mind that the finished product does not necessarily mean that the knowledge factors relating to a particular skill were taught, and achievement will have to be measured by using written or oral tests.

ADMINISTRATIVE SUPERVISION

The Company Chief supervises the clerical and administrative details of the company. He is responsible for maintaining company records and supervising the preparation of company reports (daily musters, time sheets, and so on). He must ensure that all pertinent directives and information is disseminated to enlisted personnel of the company.

PERSONNEL ADMINISTRATION

The Company Chief should pay particular attention to items that may influence morale, discipline or espirit de corps. He is generally in a better position than the Company Commander to influence other enlisted men of the company. He should, therefore, counsel enlisted personnel on any pertinent professional and personal matter which may affect efficiency. Although it may be necessary to refer some of the problems to the Company Commander, there are many matters that the Company Chief may be able to take action on. For example: When CN Pardines

is unable to obtain a pair of boots of the correct size from greens issue, the Company Chief will usually know where they may be obtained. These small problems will be many but should be corrected promptly.

Several books have been written on the subject of military leadership and as a senior petty officer you have no doubt read some of them. One book that may be of particular interest to you, as Company Chief, is The Armed Forces Officer, NavPers 15923-A. Some of the more specific duties in regards to company personnel, which may be your responsibility as a Company Chief, are given below.

The Company Chief should greet, interview and indoctrinate personnel new to the company; ensure that the Company Commander's personnel data cards and PRCP cards are prepared and kept current according to existing instructions; assign or ensure the assignment of all company personnel within a platoon, work crew, berthing space, duty section, etc.; ensure assignment and fair rotation of messmen, compartment cleaners, shore patrol, and other such duties; make recommendations to the Company Commander concerning personnel eligible for advancement; supervise and coordinate the preparation of enlisted evaluation sheets and ensure that they are fair and accurate; direct the expeditious handling of special request ships; ensure the prompt delivery of mail addressed to personnel of the company and see that mail is forwarded to persons on detachment, in hospitals, etc.; assist the Company Commander in disciplinary matters; ensure satisfactory scheduling of company personnel going on leave and R & R trips; encourage individual study and motivate eligible personnel to take advantage of programs for which they may qualify (i.e., SCORE and LDO); and coordinate company recreation projects such as parties and athletic teams.

INDEX

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P

R

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